



Type 1820
DIGITAL VOLTMETER
and Plug-In Accessories

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- 1820-A Main Frame
- 1820-P1 DC Multimeter/UHF Voltmeter
- 1820-P2 AC/DC Millivoltmeter
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Type 1820 DIGITAL VOLTMETER

The Type 1820 Digital Voltmeter consists of the Type 1820-A Main Frame and either the Type 1820-P1 or -P2 plug-in preamplifier unit. The plug-ins are interchangeable in the Main Frame and are selected with respect to the measurement in question. The Differential Adaptor, Type 1820-P3, presents a floating, fully balanced input to the voltmeter when used in conjunction with the other plug-in units. The Type 1806-P1 Tee Connector screws onto the Type 1820-P1 probe in place of the probe tip, allowing the Type 1820-A/1820-P1 combination to realize a full 1500-MHz range.

CONDENSED OPERATING INSTRUCTIONS

1820-A MAIN FRAME

The Main Frame operates only in conjunction with the Type 1820-P1 or -P2 modules; details of operation are included under the appropriate plug-in description. The following information briefly outlines the proper settings of the Main Frame controls for various modes of digital display and ranging.

Preliminary

Insert a Type 1820 plug-in unit into the Main Frame; tighten the knurled screw to secure the unit in the Main Frame.

Set the LINE switch on the rear of the instrument to the range including the line voltage to be used.

Connect the instrument to the line source via the supplied power cord and set the POWER switch to the on position.

Function

If the dB level of an ac or negative dc signal (with respect to the reference level determined by the plug-in unit used) is required, set the FUNCTION switch to LOG. For direct readout of voltage or resistance, set the FUNCTION switch to LINEAR.

Sampling Rate

For maximum sampling rate (about 30 samples per second), set the SAMPLING RATE control fully clockwise. To stop sampling and hold the meter readout, set the control to HOLD.

To control the sampling rate externally, set the SAMPLING RATE to HOLD. The voltmeter will then start a measurement cycle each time a +2-V pulse is applied between terminals 3 and 4 (ground) of the EXTERNAL SAMPLING RATE socket (rear panel).

A +10-V gate on terminal 2 will stop the instrument and hold the count until the gate is returned to zero.

Range

For automatic ranging, set the left-hand RANGE toggle switch to AUTO.

To set the voltmeter to a given range, set the left-hand switch to MANUAL, then use the right-hand switch to step the instrument through its ranges.

NOTE

Any reading above 23XX in the LINEAR mode or E3XX in the LOG mode (where E is any even integer) indicates an overload.

1820-P1 DC MULTIMETER/UHF VOLTMETER

The Type 1820-P1 plug-in measures ac voltage, dc voltage, dc current and resistance, to 0.1% accuracy in most cases. It is especially useful for high-frequency voltage measurements to 1.5 GHz and exhibits extremely high input impedance for all ranges of both ac and dc voltage. Voltage-measurement ranges extend from millivolts to kilovolts, resistance to 50 M Ω .

WARNING

Exercise caution when making connections or operating the voltmeter for any high-voltage measurement.

Preliminary

Using the instructions for the Main Frame, prepare the instrument for the desired readout with the Type 1820-P1 plug-in inserted.

If the input voltage is expected to exceed 200 V (dc or rms), set the VOLTAGE screwdriver control to X100 ATT.

Set the INPUT FILTER TIME CONSTANT according to the response required: MAX for best noise rejection, MIN for fastest response.

DC Voltage Measurement

Set the MEASUREMENT switch to DC.

Apply the unknown voltage to the INPUT terminals. The upper binding post is the high terminal, the lower left-hand post is low, and the lower right-hand post is chassis ground.

For ungrounded operation, remove the link between the lower binding posts. Do not connect the ungrounded low terminal to a signal with an ac component or a dc level greater than ± 400 V.

AC Voltage Measurement

Set the MEASUREMENT switch to AC.

Short the INPUT terminals and, with the Type 1820-A FUNCTION switch set to LINEAR, adjust the AC ZERO control so that the display alternates between 0000 and 0001.

NOTE

This adjustment has a built-in fine control. Turn clockwise for coarse, then counterclockwise for fine adjust.

For signal frequencies below 100 kHz, connect the unknown voltage directly to the INPUT terminals.

For signal frequencies above 100 kHz, sample the unknown signal with the ac probe.

CAUTION

Do not apply more than 200 V rms (280 V peak) or 600 V dc to the probe.

Resistance Measurement

Connect the unknown resistance across the input terminals; set the MEASUREMENT switch to k Ω or M Ω .

NOTE

A test voltage is applied across the INPUT terminals when the MEASUREMENT switch is in the k Ω or M Ω position. This voltage is not dangerous but may cause mild shock on contact.

1820-P2 AC/DC MILLIVOLTMETER

The Type 1820-P2 plug-in measures both ac (average) and dc signals with microvolt sensitivity. Dc current can be measured with picoampere resolution. With a standard oscilloscope current probe, ac current can be measured with nanoampere resolution. An ohmmeter capability is also included.

Preliminary

Using the instructions for the Main Frame, prepare the instrument for the desired readout with the Type 1820-P2 plug-in inserted.

If the input voltage is expected to exceed 200 V dc, set the DC VOLTAGE screwdriver control to X100 ATT.

Set the INPUT FILTER TIME CONSTANT according to the response required: MAX for the best noise rejection, MIN for the fastest response.

WARNING

Voltages up to 1000 V can be measured with this instrument, and such voltages can be dangerous. Exercise caution when making connections or when operating the voltmeter for any high-voltage measurements.

DC Voltage Measurement

The DC ZERO adjustment affects measurements on the mV dc range, and on the lower resistance and current ranges. To set the DC ZERO:

- Set the Type 1820-A FUNCTION switch to LINEAR, and RANGE to AUTO.
- Set the Type 1820-P2 measurement selector to DC.
- Short the high (H) and low (L) input terminals and adjust the DC ZERO control for a 0000 display with the polarity alternating between + and -.
- Set the measurement switch to DC.
- Apply the unknown voltage to the input terminals. The upper binding post is the high terminal, the lower left-hand post is low, and the lower right-hand post is chassis ground.

For ungrounded operation, remove the link between the lower binding posts. Do not connect the ungrounded low terminal to a signal with an ac component or a dc level greater than ± 400 V.

AC Voltage Measurement

Set the measurement switch to AC. Connect the unknown voltage directly to the input terminals. For signal frequencies above 2 MHz, use of the Type 1820-P1 plug-in is recommended in place of the Type 1820-P2.

CAUTION

Do not apply more than 200 V rms or 280 V peak to this instrument.

DC Current Measurement

To measure dc current flowing through a component, connect the high and low input terminals in series with the component.

Select the correct range on the measurement switch according to the expected current.

AC Current Measurement

A current probe, such as the Tektronix P6020, is required when measuring ac current with the Type 1820-P2. In connecting the probe a GR 274-QBJ Adaptor is required between the probe and the Type 1820-P2 input terminals. To measure ac current, open the spring-loaded slide on the probe, place the conductor (up to 0.100-in. diameter) in the probe slot, and release the slide. Set the switch on the P6020 termination to 10 mA/mV (for a low-frequency 3-dB cutoff at 935 Hz), and the Type 1820-P2 measurement switch to AC. The Type 1820 will display 100 μ V for each mA of ac current.

Resistance Measurement

To measure a resistance, connect the unknown across the input terminals and set the measurement switch to k Ω or M Ω .

NOTE

A test voltage is applied across the input terminals when the measurement switch is in the k Ω or M Ω position. This voltage is not dangerous but may cause mild shock on contact.

1820-P3 DIFFERENTIAL ADAPTOR

The Type 1820-P3 converts the dc input of the Type 1820-P1 or -P2 to a true differential input. Common-mode rejection is about 100 dB, even with a source impedance of 100 k Ω .

To measure a positive dc voltage with respect to ground, connect the signal to the A+ terminal of the adaptor and the circuit ground to either uninsulated binding post.

To measure the dc voltage between two points that are not at circuit ground, connect the higher voltage to the A+ terminal and the lower voltage to the B- terminal. Connect the circuit ground to one of the uninsulated binding posts.

1806-P1 TEE CONNECTOR

Above approximately 200 MHz the inductance of probe tips and ground leads is sufficient to cause errors in voltage measurements if the probe is used with ordinary open connections. Therefore, the Type 1806-P1 Tee Connector is needed to realize the full 1500-MHz frequency range of the probe.

To install the Type 1806-P1:

- Unscrew the gray plastic tip via the knurled ring at the base of the tip.
- While unscrewing the tip, pull on the cable with the little finger of the hand holding the body of the probe.
- Draw the inner section away from the tip.
- With the inner part still withdrawn, screw on the tee connector in place of the probe tip.

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WEST CONCORD, MASSACHUSETTS 01781

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Telephone 416 247-2171

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Telephone 514 737-3673

OTTAWA Telephone 613 233-4237

General Radio Company (Overseas), 8008 Zurich, Switzerland
General Radio Company (U.K.) Limited, Bourne End, Buckinghamshire, England
Representatives in Principal Overseas Countries

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Type 1820-A

DIGITAL VOLTMETER

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Specifications



Digital Voltmeter with 1820-P1 and 1820-P3 plug-ins.

Ranging: Manual or automatic, switch selected.

Display: Four numerals (max reading 2200 on linear ranges, 62.00 on log ranges) with decimal point and units.

Sampling Rate: 0.5 to 30 Hz, adjustable. In HOLD mode, measurement can be externally initiated by positive pulse of >2 V.

DATA OUTPUT

Numerical Data: Four digits BCD 1-2-4-2 code (1-2-4-8 with slight modification).

Other Data: Range, 3 bits; polarity, 1 bit; log/linear, 1 bit.

Print Command (at completion of measurement): Transition from "1" level to "0" level, approx 15 ms duration, impedance 2 k Ω .

Signal Levels: Logical "one" is 0 V, logical "zero" -10 V, both with respect to reference line at +10 V above ground. Impedance 57 k Ω .

Accessories Supplied: Power cord, spare fuses, bench- or rack-mounting hardware.

Accessories Available: Plug-ins and adaptor as listed, 1806-P1 Tee Connector for high-frequency voltage measurements in coax, input scanner and other GR digital-data handling equipment. Order 1137 Data Printer and two extra modules for 8-digit capacity.

Power Required: 105 to 125, 195 to 235, or 210 to 250 V, 50 to 60 Hz, 40 W.

Terminals: At rear panel, data output, ext sampling rate, and aux input terminals.

Mounting: Rack-Bench Cabinet.

Weight: Net, 30 lb (13.6 kg); shipping, 74 lb (33.6 kg).

Plug-in (approx), net 4 lb (2 kg); shipping, 10 lb (4½ kg).

Catalog Number	Description
1820-9700	1820-A Digital Voltmeter (no plug-in)
1820-9701	Bench Model
	Rack Model
	Plug-Ins and Accessories
1820-9601	1820-P1 DC Multimeter/UHF Voltmeter
1820-9602	1820-P2 AC/DC Millivoltmeter
1820-9603	1820-P3 Differential Adaptor (for use with 1820-P1 or -P2 Plug-ins)

NOTE: This instrument is equipped with our new snap-on knob for added convenience and safety. Refer to the Service Section for details.

CHANGE NOTICE

1820-A DIGITAL VOLTMETER INSTRUCTION MANUAL.

INSERT AFTER PAGE 2-4

Add the following to paragraph 2.5.2:

DATA OUTPUT CONNECTIONS

B1 1	}	THOUSANDS	A4 1	}	UNITS	B7 1	}	VOLT/mV
D1 2			C4 2			D7 GND		
F1 GND			E4 4			F7 GND		
H1 GND			G4 2*			H7 GND		
A2 1	}	HUNDREDS	B5 1	}	POLARITY	A8 1	}	LOG/LIN
C2 2			D5 GND			C8 GND		
E2 4			F5 GND			E8 GND		
G2 2*			H5 GND			G8 GND		
B3 1	}	TENS	A6 1	}	DECIMAL			
D3 2			C6 2					
F3 4			E6 GND					
H3 2*			G6 GND					

Note: All above GNDS are circuit grounds. 

A12 Print Command
H13 Chassis Ground 
C12 V REF, + 10

<u>POLARITY</u>	<u>LOG/LIN</u>	<u>DECIMAL</u>
0 = -DC, AC, Ω	0 = LOG	LIN LOG
1 = +DC	1 = LIN	0 = X.XXX 0,10 dB
		1 = XX.XX 20,30 dB
		2 = XXX.X 40,50,60 dB

<u>THOUSANDS OUTPUT ON LOG</u>	<u>RANGE</u>
6X.XX dB = 2XXX	DC AC 0-50 k Ω 0-50 M Ω
5X.XX = 1XXX	0 = mV dc mV ac Ω k Ω
4X.XX = 0XXX	1 = V dc V ac k Ω M Ω
3X.XX = 1XXX	
2X.XX = 0XXX	
1X.XX = 1XXX	
0X.XX = 0XXX	

CABLE FOR 1820/1137 PRINTER OPERATION

<u>1820 DATA</u>	<u>1137-0220 CABLE SOCKET</u>
Thousands	11
Hundreds	10
Tens	9
Units	8
Polarity	7
Decimal	6
Volt/mV	5
Log/Lin	4
Printer Control	C

(Sockets 1, 2, and 3 not used.)

(Use 1137-9604 modules with printer.)

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Introduction—Section 1

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1.1 PURPOSE

The 1820 Digital Voltmeter is a general-purpose, ramp-type digital voltmeter featuring a 4-digit (first digit limited to 0, 1, 2) readout in six linear or decibel ranges, automatic or manual ranging, automatic polarity sensing, internally or externally controlled variable sampling rate, BCD output, and a choice of high-input-impedance plug-in front-end units. Basic accuracy of the instrument is 0.1%. Ac and dc voltage, resistance, bandwidth and input impedance ranges depend on the plug-in unit used.

The voltmeter is supplied in two models: Bench mount (1820-9700) and rack mount (1820-9701).

1.2 DESCRIPTION

The Digital Voltmeter comprises the main frame and a preamplifier plug-in unit. The main frame, which is the subject of this instruction manual section,

contains the power-supply, digital-display, digital-output and ranging logic circuits. Each plug-in unit contains a rectifier, a chopper-stabilized preamplifier, and one or more linearizing networks. The number of ranges and the types of measurement possible with the voltmeter depend on the type plug-in unit used.

The basic measurement action of the Type 1820 is a comparison of the input signal with an internally generated ramp voltage. The time taken by the ramp to reach the unknown signal level is measured by an internal clock, and, because the ramp rate is accurately controlled, this time is a measure of the unknown level.

Controls on the Type 1820 determine the ranging mode, the type of display and digital output produced, and how often the unknown is to be measured. All other controls, for example, the MEASUREMENT (AC, DC, etc) switch, as well as the main unknown input terminals, are located on the plug-in.

1.3 FRONT CONTROLS, CONNECTORS, AND INDICATORS

<i>Ref. No. (Figure 1-1)</i>	<i>Name</i>	<i>Description</i>	<i>Function</i>
1	POWER	2-position toggle switch	Controls ac line input.
2	RANGE	2-position toggle switch	Selects ranging mode: AUTO position - voltmeter range selected automatically by instrument. MANUAL position - voltmeter range selected manually by operator, with RANGE manual control.
3	RANGE manual control	3-position spring-loaded toggle switch	Causes voltmeter to step through ranges; when held in INCREASE position, voltmeter range steps up to 220 V and stops; when held in DECREASE position, voltmeter range steps down to 220 mV with P1 plug-in (2 mV with P2 plug-in) and stops.
4	FUNCTION selector	2-position rotary switch	Determines whether digital readout indicates ac or dc volts (or ohms) directly (LINEAR position) or relative voltage and resistance in terms of dB (LOG position).
5	SAMPLING RATE control	Rotary control with concentric 2-position switch	Adjusts rate at which input voltage is sampled from once every 2 s to 30 times per s. In HOLD position, the voltage is sampled once and the measured value displayed for an unlimited amount of time. Also with the control in the HOLD position, the sampling rate can be controlled by an external positive >2-V pulse applied to the EXTERNAL SAMPLING RATE socket.
6	Numerical indicators	Numerik Digital Indicators, KGM Electronics Ltd. Type No. M/18	Indicate measured voltage or resistance, polarity, units, and location of decimal point.
7, 8	Plug-in sockets	24- and 32-pin sockets, Amphenol Nos 26-4500-24P and -32P	Signal and power connectors for plug-in unit. Refer to Figure 6-2 for a listing of pin functions.

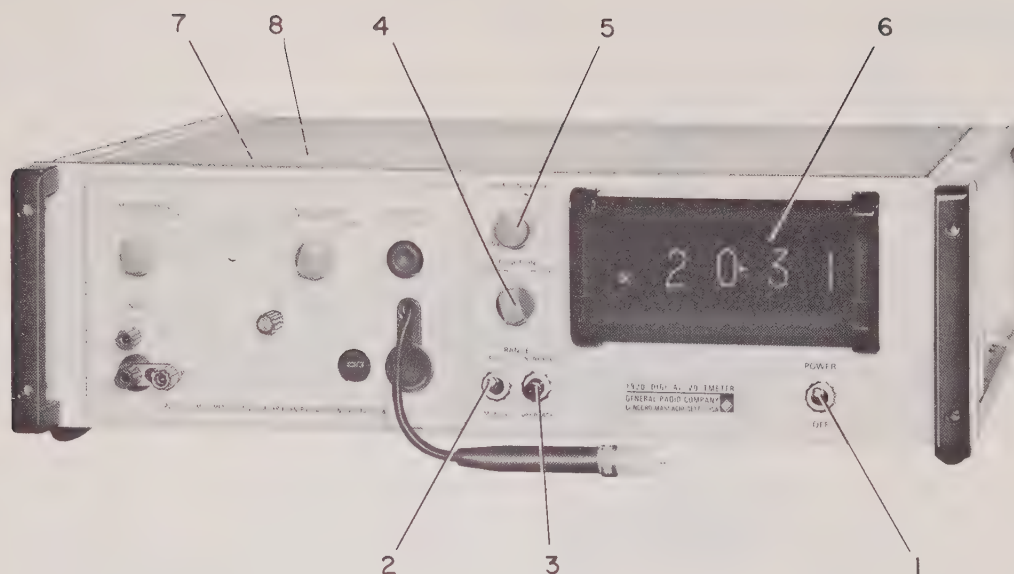


Figure 1-1. Type 1820 Digital Voltmeter controls, connectors, and indicators, front.

1.4 REAR CONTROLS AND CONNECTORS

Ref. No. (Figure 1-2)	Name	Description	Function
1	Line fuses	(2) 0.5-A, Slo-Blo (2) 0.25-A, Slo Blo	For 105- to 125-V operation. For 210- to 250-V operation.*
2	Power input connector	3-pin, 7-ft power plug	For connection to ac power line.
3	LINE voltage selector	2-position slide switch	Connects instrument power transformer. For use with 105- to 125-V or 210- to 250-V* input power.
4	EXTERNAL SAMPLING RATE socket	4-connector socket, Jones Part No. 5-304-AB, accepts a Jones 4-connector plug, Part No. 261-31-04-030.	For application of a positive >2-V pulse to control sampling rate of voltmeter. Refer to paragraph 2.5.1 for a listing of pin functions.
5	DATA OUTPUT connector	52-pin socket, Amphenol No. 220-698-01, accepts Amphenol No. 220-697-01 plug.	For BCD coded output of measured voltage or resistance. Refer to Figure 6-2 for a listing of pin functions.
6	Auxiliary INPUT connectors	Type 938 jacks, 3/4-in. spaced, accept GR 274 and GR 938 banana plugs.	For connection of input signal. Connected to INPUT jacks located on front of plug-in unit.

* The instrument normally operates from 195- to 235-V power with the LINE selector in the 210- to 250-V position. Rewiring for 210- to 250-V operation is detailed in paragraph 5.5.

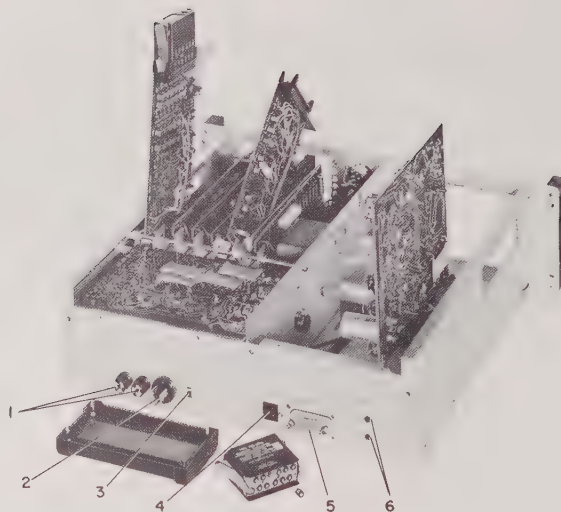


Figure 1-2. Type 1820 Digital Voltmeter controls and connectors, rear.

1.5 ACCESSORIES SUPPLIED

Quantity	Description	Part Number
1	Instruction book	1820-0100
1	Power cord, 3-wire, 7-ft	4200-9622
1	Fuse, 0.25-A Slo-Blo for 210- to 250-V or 195- to 235-V operation (spare)	5330-0700
1	Fuse, 0.5-A Slo-Blo for 105- to 125-V operation (spare)	5330-1000
<i>For bench model:</i>		
1	End-frame set	5310-9636
<i>For rack model:</i>		
1	Rack-support set	7863-9636

1.6 PLUG-IN UNITS

1.6.1 GENERAL.

The choice of which plug-in preamplifier to use in the Type 1820 depends on the type of measurement to be made. The following paragraphs outline the special advantages of each type of plug-in available for the voltmeter. All plug-in units contain chopper-stabilized preamplifiers, provisions for feedback from the main frame, and one or more linearizing networks.

1.6.2 TYPE 1820-P1 DC MULTIMETER/UHF VOLTMETER.

The Type 1820-P1 plug-in unit is best suited for measuring voltage of ultra-high-frequency up to about 1.5 GHz, for measuring dc voltages greater than about

20 mV when extremely high input impedance ($10^{11} \Omega$) is required, and for measuring high values of resistance (from about 25 k Ω to 50 M Ω). Specifications for the Type 1820-P1 are listed in its own instruction manual.

1.6.3 TYPE 1820-P2 AC/DC MILLIVOLTMETER.

The Type 1820-P2 is best suited for measuring low-level ac and dc voltages down to microvolts, for measuring very small dc currents down to picoamps, and for measuring resistances between about 2 Ω and 20 M Ω . Bandwidth of the Type 1820-P2 is 50 Hz to 100 kHz for a basic measurement accuracy of 0.2%, 20 Hz to 2 MHz for 2% accuracy. Input impedance is $10^9 \Omega$ on dc. Complete specifications for this plug-in are listed in its own instruction-manual section.

1.7 CABLE ASSEMBLIES

1.7.1 4205-1010 UNIVERSAL CABLE, ONE CONNECTOR.

The 4205-1010 universal-cable assembly is primarily intended to connect non-GR instruments to the DATA OUTPUT socket.

1.7.2 4205-1000 UNIVERSAL CABLE, TWO CONNECTORS.

The 4205-1000 universal cable assembly is identical to the 4205-1010 cable assembly, above, except both ends are terminated in 52-pin plugs.

Figure 1-3.
The Type 4205-1010
Universal Cable Assembly.

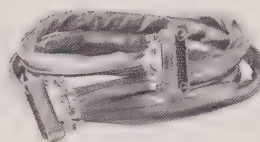
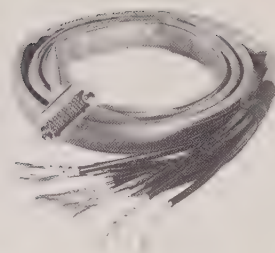


Figure 1-4.
The Type 4205-1000
Universal Cable Assembly.

TABLE 1-1
Connections of the 4205-1010 Universal Cable Assembly

Plug Pin	Lead		Plug Pin	Lead		Plug Pin	Lead	
	Group	Color		Group	Color		Group	Color
B1	1	brown	B5	5	brown	B9	9	brown
D1		red	D5		red	D9		red
F1		orange	F5		orange	F9		orange
H1		yellow	H5		yellow	H9		yellow
A2	2	brown	A6	6	brown	A10	10	brown
C2		red	C6		red	C10		red
E2		orange	E6		orange	E10		orange
G2		yellow	G6		yellow	G10		yellow
B3	3	brown	B7	7	brown	B11	11	brown
D3		red	D7		red	D11		red
F3		orange	F7		orange	F11		orange
H3		yellow	H7		yellow	H11		yellow
A4	4	brown	A8	8	brown	A12	12	brown
C4		red	C8		red	C12		red
E4		orange	E8		orange	E12		orange
G4		yellow	G8		yellow	G12		yellow
						H13	C	black
						B13		green
						D13		blue
						F13		white

1.8 SUPPLEMENTARY EQUIPMENT AVAILABLE

1.8.1 DIGITAL RECORDING.

The Type 1820 Digital Voltmeter can be used with the Type 1137 Data Printer to record data permanently in digital form.

1.8.2 ANALOG RECORDING.

The Digital Voltmeter can be used with the Type 1510 Digital-to-Graphic Recording Assembly to record data permanently in analog form. The Type 1510 comprises a Type 1136 Digital-to-Analog Converter and a Type 1521 Graphic Level Recorder.

1.8.3 SCANNING VOLTAGES OR RESISTANCES.

The Type 1770 Scanner System, which consists of one Type 1771 Scanner Control and one or more Type 1772 Scanner Switch units, is an automatic instrument for the sequential connection of many pairs of terminals to a signal pair. The scanner may have up to 100 input channels, which it connects in sequence to a single output channel, which can be connected, for instance, to the input of the Type 1820. The scanner sequence may be activated by an external command or by an internal program. Alternatively, external programmed equipment can make non-sequential channel selection with BCD inputs to the scanner.

1.8.4 GO-NO-GO TESTING.

The Type 1781 Digital Limit Comparator automatically compares the BCD output of a measuring instrument, such as the Type 1820 Digital Voltmeter, with limits that are preset (with appropriate range) on front panel thumbwheels. Panel lights indicate whether or not the measurement is within tolerance, and relay contacts actuate external GO-NO-GO indicators or sorting equipment.

1.8.5 SYSTEMS.

Since the digital voltmeter can be the nucleus of a larger measurement system, General Radio will arrange to supply complete systems that incorporate a large variety of auxiliary instrumentation. Inquiries are invited.

The instrumentation can include auxiliary input devices such as conveyor-sorting, reel-type-handling or stick-and-indexer equipment, scanners, environmental test chambers, and transducers to convert temperature to voltage, etc.

Output devices can also be supplied, such as data printers, digital-to-analog converters, dc recorders, x-y recorders, limit comparators for component sorting, card or tape punches with the necessary intercouplers, magnetic tape recorders, and typewriters.

Also available is such ancillary equipment as clocks for time of day records (Type 1123 Digital Synchornometers with Type 1115 Standard-Frequency Oscillators) and electronic counters for serial number records (Types 1191 Counter and 1159 Recipromatic Counter).

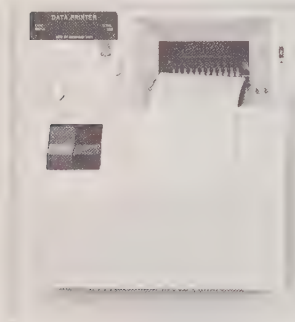


Figure 1-5.
The Type 1137 Data Printer.

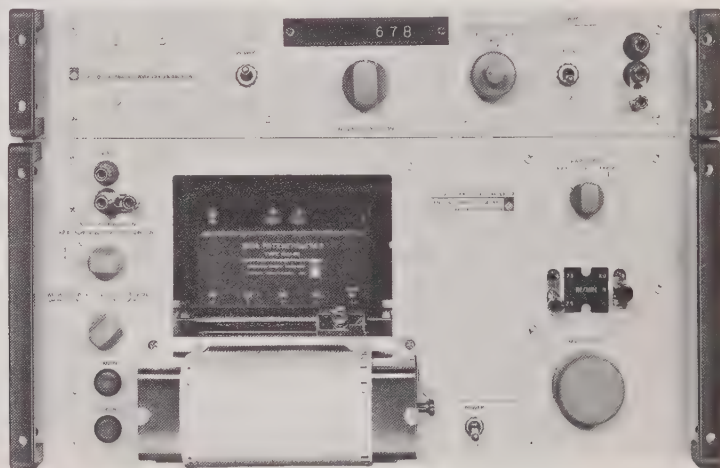


Figure 1-6.
The Type 1510 Digital-to-Graphic Recording Assembly.

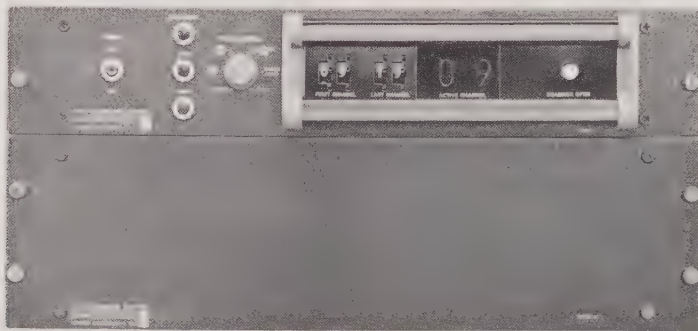


Figure 1-7.
The Type 1770 Scanner System.

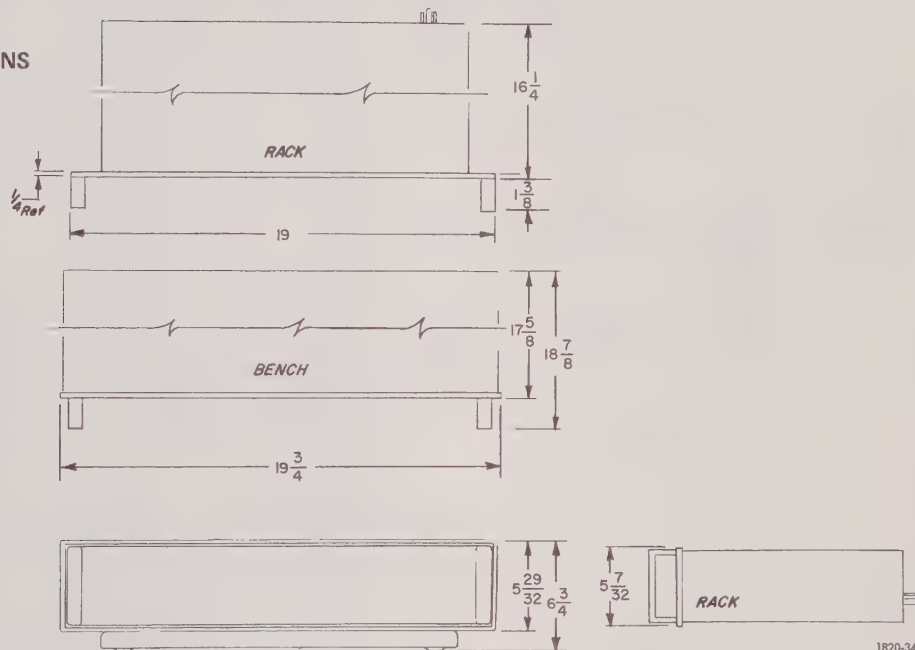


Figure 1-8.
The Type 1781 Digital Limit Comparator.

Installation—Section 2

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2.1 DIMENSIONS



DIMENSIONS ARE IN INCHES

2.2 POWER CONNECTION

Use the Type CAP-22 Three-Wire Power Cord supplied to connect the instrument to a source of power in agreement with the setting of the LINE switch. Power consumption is 40 W. The long cylindrical pin (ground) is connected directly to the metal case of the instrument. The power transformer is normally wired and fused for 105- to 125-V or 195- to 235-V,* 50- to 60-Hz, operation but can be rewired for 210- to 250-V operation. Refer to paragraph 5.5 for instructions on rewiring the Type 1820 for operation from a 210- to 250-V power line.

2.3 MOUNTING

2.3.1 BENCH MODEL.

2.3.1.1 Positioning.

The bench model (P/N 1820-9700) is ready to use as received. The bench cabinet has one adjustment that allows the instrument panel to be tilted upward

toward the operator. To tilt the instrument, proceed as follows:

- Place the right thumb on the right-hand release toggle and the left thumb on the left-hand release toggle (Figure 2-2).

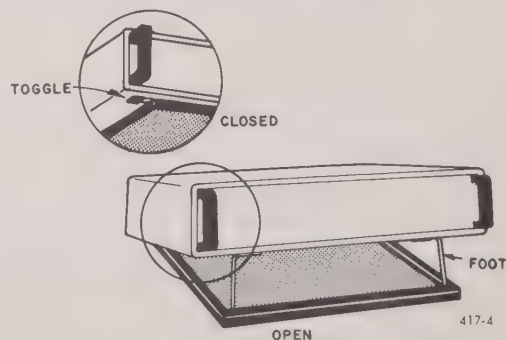


Figure 2-2. Type 1820 bench model positioning.

*Although labelled "210- to 250-V" on the LINE switch.

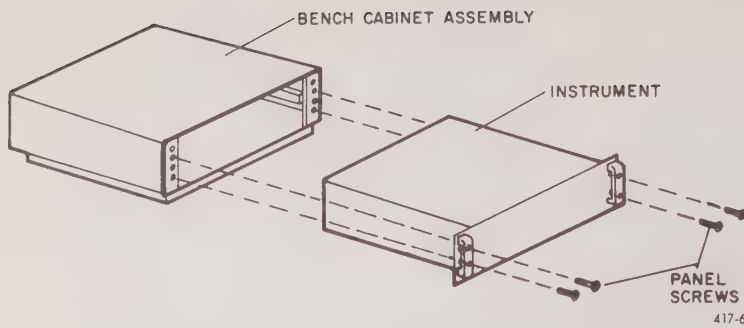


Figure 2-3.
Removing the bench model from its cabinet.

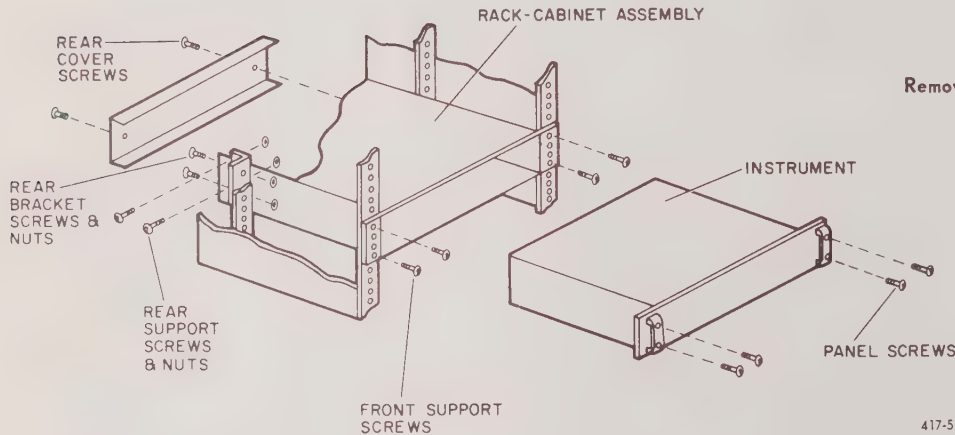


Figure 2-4.
Removing the rack model from its cabinet.

b. Push each toward the rear of the cabinet until they stop.

c. Lift the front of the instrument upward (the rear of the pedestal is the pivot).

d. When the feet are perpendicular to the pedestal, hold the instrument with one hand and pull the feet forward to the front of the pedestal with the other hand. The instrument is now ready to operate in the tilted position.

2.3.1.2 Removing the Instrument.

To remove a bench-mounted instrument from its cabinet, proceed as follows:

a. Remove the four screws (P/N 7270-6310, No. 10-32, 9/16 in. with nylon washer) from the front panel (Figure 2-3).

b. Pull the instrument out from the front of the cabinet.

2.3.2 RACK MODEL.

To mount the rack model (P/N 1820-9701) in an EIA 19-inch relay rack, proceed as follows:

a. Remove the panel screws (P/N 7270-6310, No. 10-32, 9/16 in. with nylon washer) and slide the instrument out of its cabinet (Figure 2-4).

b. Insert the cabinet in the rack and secure it to the front of the rack with the four front-support screws provided (P/N 7080-1500, No. 10-32, 1/2 in.).

c. If the rack contains a rear support, remove the rear-cover screws and remove the rear cover. Attach the brackets (P/N 4171-8520, 1-1/4-in. sides, 2-3/4-in. long) to the cabinet with the four rear-bracket screws (P/N 7080-1500, No. 10-32, 1/2 in.), washers (P/N 5810-3300, No. 10-32, hexagonal) provided; use the set of slots that most nearly aligns the bracket with the rear support. Secure the bracket to the rear support.

d. Place the rear of the instrument in the cabinet. Push the instrument all the way in and secure it to the rack with the panel screws.

2.4 INPUT SIGNAL CONNECTION

The INPUT connectors are standard, 3/4-inch-spaced binding posts that accept banana plugs, stand-alone telephone tips, alligator clips, crocodile clips, spade terminals, and all wire sizes up to number 11. A wide variety of GR patch cords is also available, as well as a full line of adaptors to convert the INPUT terminals for use with most commercial and military coaxial connectors.

2.5 SUPPLEMENTARY CONNECTIONS

2.5.1 EXTERNAL SAMPLING RATE.

A four-connector Jones-type socket on the rear of the instrument allows the application of a timing signal to the voltmeter's clear-pulse driving circuit (see Fig. 2-5). When the SAMPLING RATE control is in the HOLD position, a 2-V positive pulse applied between

TABLE 2-1
Available Patch Cords and Adaptors



Panel
Connectors

NOTE: GR874 connectors are 50 Ω and are mechanically sexless; i.e., any two, although identical, can be plugged together.

	TYPE NO.	DESCRIPTION	CATALOG NO.
	274-NQ	Double-plug patch cord, in-line cord, 36" long	0274-9860
	274-NQM	Double-plug patch cord, in-line cord, 24" long	0274-9896
	274-NQS	Double-plug patch cord, in-line cord, 12" long	0274-9861
	274-NP	Double-plug patch cord, right-angle cord, 36" long	0274-9880
	274-NPM	Double-plug patch cord, right-angle cord, 24" long	0274-9892
	274-NPS	Double-plug patch cord, right-angle cord, 12" long	0274-9852
	274-NL	Shielded double-plug patch cord, 36" long	0274-9883
	274-NLM	Shielded double-plug patch cord, 24" long	0274-9882
	274-NLS	Shielded double-plug patch cord, 12" long	0274-9862
	274-LLB	Single-plug patch cord, black, 36" long	0274-9468
	274-LLR	Single-plug patch cord, red, 36" long	0274-9492
	274-LMB	Single-plug patch cord, black, 24" long	0274-9847
	274-LMR	Single-plug patch cord, red, 24" long	0274-9848
	274-LSB	Single-plug patch cord, black, 12" long	0274-9849
	274-LSR	Single-plug patch cord, red, 12" long	0274-9850
	1560-P95	Adaptor cable, double-plug to telephone plug, 36" long	1560-9695
	874-R34	Coaxial patch cord, double plug to GR874, 36" long	0874-9692
	874-R33	Coaxial patch cord, two plugs to GR874, 36" long	0874-9690
	274-QBJ	Adaptor, shielded double plug to BNC jack	0274-9884
	776-A	Patch cord, shielded double plug to BNC plug, 36" long	0776-9701
	776-B	Patch cord, GR874 (right-angle) to BNC plug, 36" long	0776-9702
	776-C	Patch cord, BNC plug to BNC plug, 36" long	0776-9703
	776-D	GR874 to GR874, both right-angle, 36" long	0776-9704

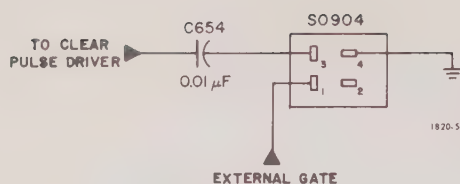


Figure 2-5.
Wiring diagram of the
EXTERNAL SAMPLING RATE socket.

pins number 3 and 4 (ground) of this socket will initiate the measurement cycle of the voltmeter. Maximum sampling rate is about 30 Hz. Pin 1 of this socket is used for remote operation of the SAMPLING RATE control. A +10-V gate at pin 1 will put the voltmeter in HOLD position regardless of the setting of SAMPLING RATE control. No connection or 0 V on pin 1 will enable the voltmeter to operate at the sampling rate set by the SAMPLING RATE control.

2.5.2 DATA OUTPUT.

The 52-pin connector, labelled DATA OUTPUT, at the rear of the instrument is a source of voltages that can be used to drive a printer, converter, or other accessory equipment.

The output consists of fourteen BCD digits at a level of 0 or +10 V, each behind 60 kΩ; +10-V power, ground, range indicators, polarity indicator, dB-scale indicator, and a print-command pulse.

NOTE

The normal connection for these BCD digits is 1-2-4-2 code. For 1-2-4-8 code, remove diode CR 406.

The explanation of the printer output numerals appears in Table 2-2.

Figure 6-2 is a diagram of the DATA OUTPUT socket.

Cables for connecting the Type 1820 to other equipment, such as digital recorders, comparators, or digital-analog converters, are described in paragraph 1.7 of this manual.

TABLE 2-2
Printer Output Numerals

<i>Digit</i> (left to right)		<i>Printer Output</i>
1	Most significant digit	0, 1, 2
2	2nd most significant digit	0 - 9
3	3rd most significant digit	0 - 9
4	4th most significant digit	0 - 9
5	Polarity indication	1 for (+), 0 for (-) 0 for extreme left
6	Range (DECIMAL)	1 for middle 2 for extreme right
7	Range (V-mV)	0 for mV; 1 for V
8	LOG-LIN	0 for LOG; 1 for LIN

Note: On log printer readouts, the range information must be added to the most significant digit as follows: (The display shows this automatically.)

<i>Decimal</i>	<i>V-mV</i>	<i>Add to First Digit</i>
0	0	0 dB
1	0	20 dB
2	0	40 dB
0	1	60 dB
1	1	80 dB
2	1	100 dB

Operating Procedure – Section 3

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3.4 Sampling Rate Control	3-2
3.5 Ranging	3-2
3.6 Data Output	3-2
3.7 Basic Accuracy	3-2

3.1 PRELIMINARY

Select a Type 1820 plug-in unit according to the signal level and frequency of the voltage to be measured, and insert it into the main unit. Tighten the knurled screw in the center of the plug-in to secure it to the main unit.

Connect the instrument to a source of ac power according to the instructions in the INSTALLATION section.

Turn the POWER on.

NOTE

When the Type 1820-P1 plug-in is used the AC ZERO should be adjusted for best accuracy. With the voltmeter on the 2-V AC LINEAR range and the INPUT shorted, adjust the AC ZERO for a readout of 0.000 to 0.003.

Because a ceramic thermionic diode is used in the probe, the zero will drift until the probe has reached thermal equilibrium. The drift is most noticeable on the 2-V range, where the AC ZERO adjustment also has the largest effect and, therefore, should be checked periodically if this range is in use. If the 20- and 200-V AC ranges are in use, the AC ZERO adjustment is less critical, although the adjustment must still be made on the 2-V range before a higher range is selected.

3.2 OPERATIONAL CHECK

The following check can be made to assure the operator that the Type 1820 main-frame circuits are operative. Set the controls of the digital voltmeter as follows:

FUNCTION	LINEAR
SAMPLING RATE	centered
RANGE	AUTO
MEASUREMENT (plug-in)	DC

Short the plug-in unit input terminals. The counter should display 0000 on its lowest range (adjustable

with -P2), and the sign of the readout should alternate between + and - at one half the rate determined by the SAMPLING RATE control. (The sign changes after every other sample.) Set the RANGE switch to MANUAL and hold the RANGE manual control at INCREASE. The counter should read 0000 in each of its ranges. Remove the short from the input terminals.

Set MEASUREMENT switch to AC and the RANGE switch to AUTO. Apply an ac voltage to the input terminals. The power-line voltage can be used. The Type 1820 should display the correct ac voltage. Remove the ac signal input.

3.3 FUNCTION SELECTION

If the dB level of an ac or negative dc signal (with respect to the reference level determined by the plug-in unit used) is required, set the FUNCTION switch to LOG. The reference level set by the Type 1820-P1 is 100mV. The Type 1820-P2 reference level is 100 μ V. The dB ranges available with the various plug-in units are listed in Table 3-1. The BCD output of the Type 1820 will not be the same as the display in the LOG mode. It will correspond rather to the actual internal count (refer to paragraph 4.8.3) and will be as indicated in Table 3-1. The socket pins at which the signals occur are shown in Figure 6-2.

There is no overlap between ranges in the LOG mode, so, if a signal level is near the edge of a range it may be more convenient to use manual ranging (paragraph 3.5).

To measure relative positive dc levels not greater than 400V, set the FUNCTION switch to LOG and use the ungrounded mode of plug-in operation to measure the inverted (signal ground to high input terminal, signal high to low input) signal.

CAUTION

Refer to the paragraph on ungrounded operation in the plug-in instruction manual before applying a signal to the ungrounded plug-in terminals.

For direct readout of voltage or resistance, set the FUNCTION switch to LINEAR. There is a 10% overlap between ranges in this mode.

TABLE 3-1.
Log Mode Data

Plug-In Used	dB Range Limits for AC Measurements		dB Range Limits for -DC Measurements		Corresponding BCD Output			
	Lower	Upper	Lower	Upper	Of Lower Limit Display	Of Upper Limit Range	Of Upper Limit Display	Of Upper Limit Range
Type 1820-P1 (ref 100mV)	-	-	+46 -60 = -14	+62 -60 = 2	0600	000	2200	000
	6*	22	2*	22	0200 (0600 AC)	101	2200	101
	22	42	22	42	0200	011	2200	011
	42	62	42	62	0200	001	2200	001
		dB Range Limits for AC and -DC						
		Lower	Upper					
Type 1820-P2 (ref 100μV)	6*	22			0600	100	2000	100
	22	42			0200	010	2000	010
	42	62			0200	000	2000	000
	02 + 60 = 62	22 + 60 = 82			0200	101	2000	101
	22 + 60 = 82	42 + 60 = 102			0200	011	2000	011
	42 + 60 = 102	62 + 60 = 122			0200	001	2000	001

*The accuracy of the digital voltmeter cannot be specified for readings below these values.

3.4 SAMPLING RATE CONTROL

For the maximum sampling rate (about 30 samples/s) set the SAMPLING RATE control fully clockwise. To stop sampling and hold the meter readout, set the SAMPLING RATE control to HOLD.

To control the sampling rate externally, set the SAMPLING RATE control to HOLD. The instrument will start a measurement cycle each time a +2-V (or greater) pulse is applied to terminals 3 and 4 (ground) of the EXTERNAL SAMPLING RATE socket on the rear of the instrument. A diagram of this socket is shown in Figure 2-5. The maximum sampling rate is, as with internal control, about 30 per second.

3.5 RANGING

For automatic ranging, set the RANGE (left-hand) switch to AUTO. If the input voltage is in a hysteresis region (220.0 mV to 0.200 V, 2.200 V to 02.00 V, etc), the decimal-point position will be determined by the range of the previous display. Otherwise, the instrument will display the input voltage or resistance level in the lowest 0200-to-2200 range allowable, without spillover of the most significant digit.

To set the voltmeter to a given range, set the RANGE (left-hand) switch to MANUAL, and use the range manual control switch to step the instrument through its ranges. Hold the switch up to increase the range, down to decrease.

NOTE

Any reading above 23XX in LIN is overload and therefore inaccurate. Any reading above E3XX in LOG is also overload. (E is an even number.)

3.6 DATA OUTPUT

The measurement results produced by the Type 1820 are available in 1-2-4-2 BCD form at the DATA OUTPUT connector at the rear of the instrument. The

pin connections of this socket are shown in Figure 6-2. The data available include: (1) the 4 digits of the digital display (except in the LOG mode, as explained in paragraphs 3.3 and 4.8.3); (2) 3 bits of range information (the logic table for this information is shown in Table 3-2); (3) one bit for polarity information ("1" for plus, "0" for minus), and one bit for FUNCTION information ("0" for LOG, "1" for LINEAR). The "1" signal level is 0 V, and the "0" level is -10 V, both with respect to a reference level, which is +10 V above circuit ground. Output impedance for all BCD signals is 57 kΩ.

A print command signal also occurs at pin A12 of the DATA OUTPUT connector. This signal is a 15-ms, negative 10-V pulse supplied from behind 2 kΩ.

A reference voltage of +10 V behind 2 kΩ is available from pin C12 of the DATA OUTPUT connector.

TABLE 3-2.
Range BCD-Output Logic.

Display	Pin A6	Pin C6	Pin B7 (V, mV)
XXX.X mV	0	0	0
XX.XX mV	0	1	0
X.XXX mV	1	0	0
XXX.X V	0	0	1
XX.XX V	0	1	1
X.XXX V	1	0	1

3.7 BASIC ACCURACY

The accuracy of individual measurements depends on the type of plug-in unit used. The limitation on accuracy imposed by the main frame is that determined by the linearity of the sweep signals, the sensitivity of the comparators, the stability of the sweep reference voltages, and the accuracy of the driver oscillator or "clock". This accuracy is ±0.08% and is obtainable with the calibration procedure outlined in paragraph 5.6.

3-2 OPERATING PROCEDURE

Principles of Operation--Section 4

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4.2 Over-all Operation in Detail	4-1
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4.8 The Range-Control Circuits	4-10
4.9 The Power Supply	4-12

4.1 GENERAL

The Type 1820 is a ramp-type 4-digit voltmeter (first digit limited to 0,1,2) with automatic polarity and ranging. The main unit is equipped for six voltage ranges, but the actual number of ranges used depends on the plug-in preamplifier employed. There are eight operational units comprising the digital voltmeter: the input preamplifier, the main amplifier, the sweep and comparator circuits, the counter, the polarity-control circuits, the range-control circuits, the data-output circuit, and the power supplies. These units are described individually in paragraphs 4.3 through 4.9.

The input preamplifier, which is contained in the plug-in unit, is chopper stabilized by an assembly of two photo-resistors and their neon-bulb drivers. These bulbs are driven alternately by a 300-Hz oscillator, which is described in the paragraphs entitled Main Amplifier, since it is physically part of that section of the instrument.

The operation of the Type 1820, described more precisely in subsequent paragraphs, is roughly as follows (see Figure 4-1): the unknown input voltage is applied via the main amplifier to one side of the comparator circuit. When a measurement cycle is started by the sampling-rate-oscillator circuit (SRO), the counter begins to count down from its upper limit, 2999. At a count of 2393 (explained in paragraph 4.2) the counter triggers a sweep voltage whose level descends at a rate exactly corresponding to the rate of decrease of the number in the counter. This sweep

voltage is applied to the other side of the comparator. When the sweep voltage, and therefore the counter number, reaches the input-voltage value, the comparator stops the count. The range and polarity logic circuits decide whether the range and polarity the counter happens to have displayed are correct. If they are, a print-command pulse occurs. If not, the range or polarity is changed, and further counting cycles occur until the logic circuits are satisfied.

4.2 OVER-ALL OPERATION IN DETAIL

4.2.1 LINEAR OPERATION.

Operation of the Type 1820 may be understood with the aid of the block diagram of Figure 4-1 and timing diagram of Figure 4-2, which illustrates the sequence of events that occur when a voltage measurement is made. The timing diagram presents a worst-case example, since the circuits must change polarity and step from the lowest to the highest voltage range.

At the beginning of the measurement sequence, the input voltage, after being chopped and amplified by the plug-in unit, is applied to the main amplifier. The gain of this amplifier is determined by the range control circuits, and, since the voltmeter is originally (in this example) in its lowest voltage range (with the Type 1820-P1), this gain is maximum. Maximum gain is much more than required for the 50-V applied signal, so the amplifier saturates, producing an output volt-

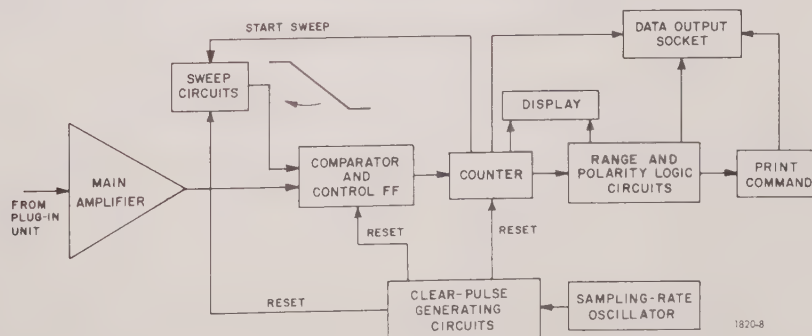


Figure 4-1. Simplified block diagram of the Type 1820-A. Blocks represent logical rather than functional units.

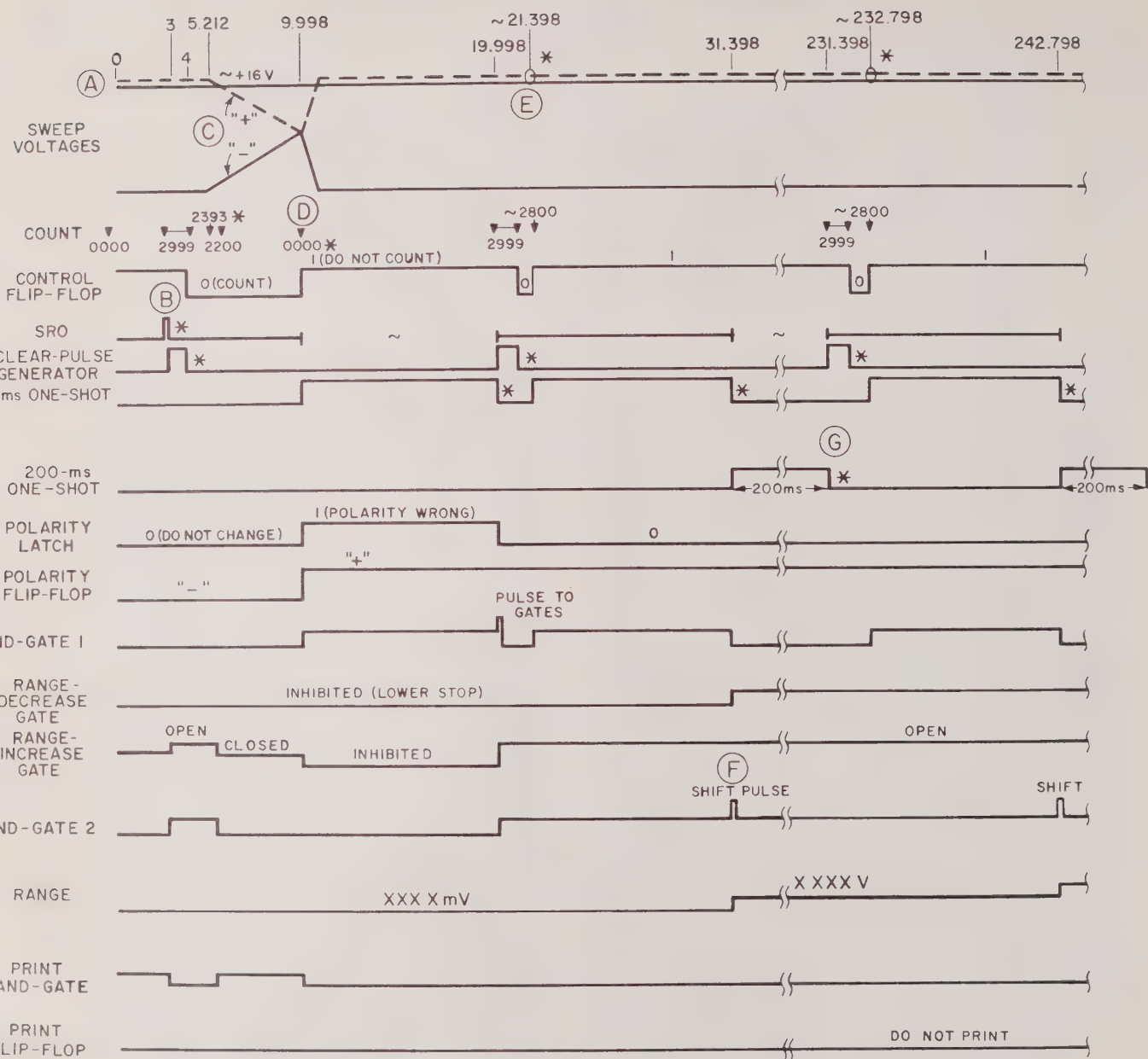
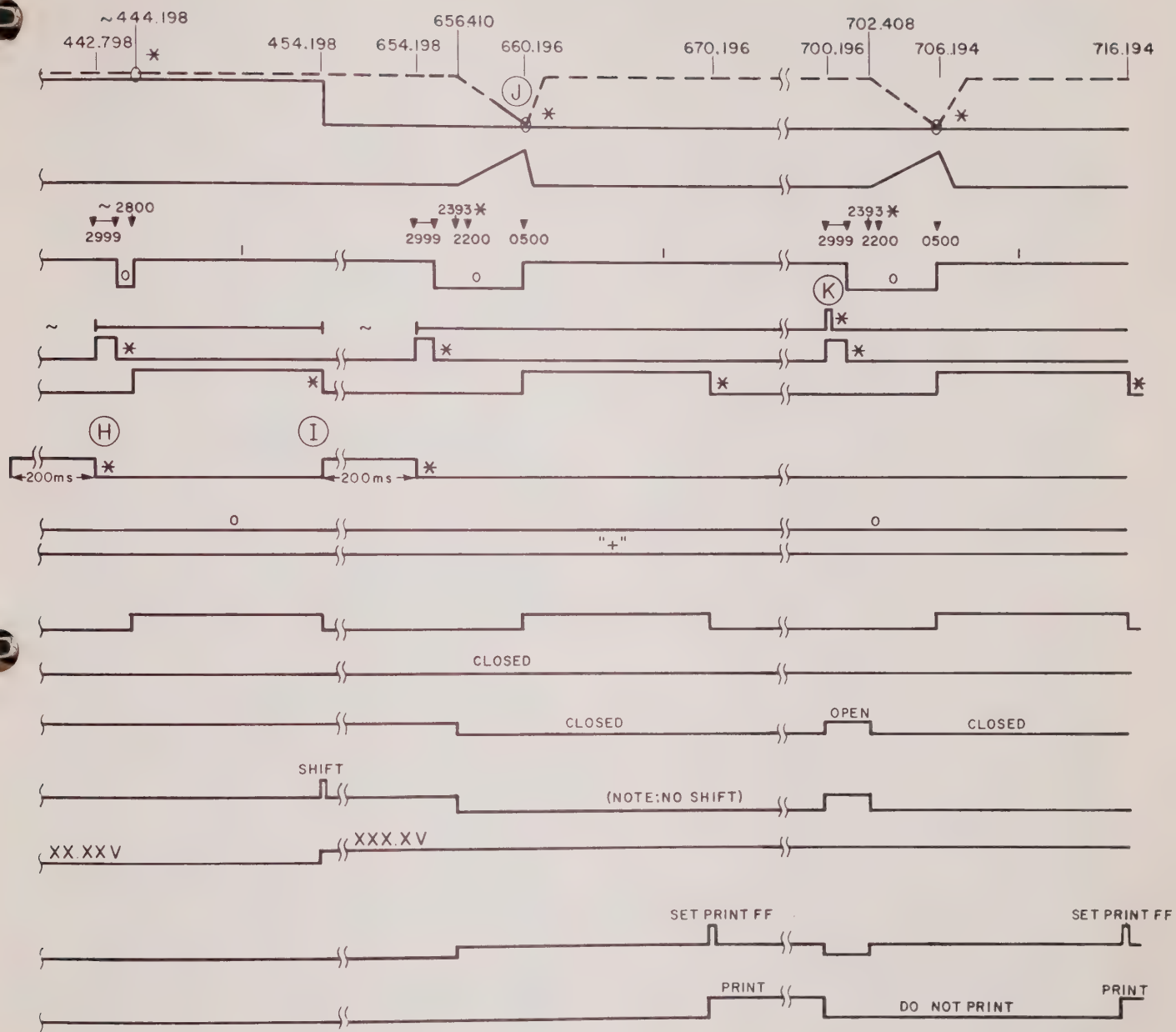


Figure 4-2. Timing diagram for a worst-case linear voltage measurement.



1820-9X

Figure 4-2. Timing diagram for a worst-case linear voltage measurement.

TABLE 4-1.
Time Sequence for Logarithmic Readout.

Initial Conditions: FUNCTION set LOG, RANGE set AUTO, SAMPLING RATE set ccw (sampling rate about 30 Hz; SRO pulse every 30 ms), initial readout is 30.00 dB.		
<i>Elapsed Time (milliseconds)</i>	<i>Event</i>	<i>Results</i>
0	+0.316 V applied to INPUT terminals	On the range that the Type 1820 is in, this voltage is less than the voltage the logarithmic sweep will reach after 2393 counts (1.26 V)
3	Sampling-rate oscillator (SRO) pulses	Clear pulse initiated, with results: A ₁) Print-command flip-flop inhibited B ₁) Polarity latch reset ("0"), with results: 1) Print and-gate enabled 2) Range-change gates opened (enabled) C ₁) Counter set 2999
4	Clear pulse ends	D ₁) Control flip-flop reset, with results: 1) Counting gate open (count starts) 2) 2393-and-counting gate enabled
5.212	Count reaches 2393	Sweep circuits start
9.998	Count reaches 0000	0000 and-gate pulses, with results: A ₂) Wrong-polarity latch set, with results: 1) Print and-gate inhibited 2) Wrong-polarity and-gate 1 half enabled 3) Range-decrease gate enabled B ₂) Control flip-flop set "0", with results: 1) Counting gate inhibited 2) 2393-and-counting gate inhibited 3) 10-ms one-shot starts timing, which, with wrong-polarity signal, stops SRO timing
19.998	10-ms one-shot pulses	Pulse through delay-over-and-range-wrong gate 2 triggers 200-ms one-shot and shifts range down (a clear pulse is not generated)
219.998	200-ms one-shot pulses	Clear pulse initiated with results A ₁ through D ₁
222.210	Count reaches 2393	Sweep circuits start
224.996	Count reaches 1000	Sweep comparator sets control flip-flop to "0", with results: A ₃) Control flip-flop set "0", which: 1) Inhibits counting gate 2) Inhibits 2393-and-counting gate 3) Triggers 10-ms one-shot
234.996	10-ms one-shot pulses	Fully enabled print-and-gate sets print flip-flop to print command
249.998	SRO pulses	New measurement cycle starts (A ₁ through D ₁)

age at TP105 and at the input to the sweep comparators of about 16 V (point A).

Some time after the input signal is applied, the sampling-rate oscillator (in the measurement-control section) pulses to start the measurement cycle (point B). This pulse generates a clear pulse, which prepares all the control circuits for a measurement. In particular, the clear pulse resets the control flip-flop.

This flip-flop is the heart of the Type 1820. Resetting it starts the counting unit, which counts down from 2999, as set by the clear pulse.

When the count of 2393 is reached, the start-sweep flip-flop is set to the "1" state, which causes the sweeps to start (point C). The 1.212-ms delay (between 2999 and the 2393 count) allows the logic circuits and the comparator circuits to settle down before

the sweeps start. A further delay, between the count of 2393 and 2200, allows the sweep voltage to achieve linearity after an initial transient. The number 2393 was chosen because it was the easiest to obtain logically from the counter's BCD output after the required delay. Since the $-$ comparator is the one that happens to be enabled, no stop-sweep signal is produced this time, and the count goes to 0000 (point D). The 0000 count sets the control flip-flop to "0", ending the first counting cycle and beginning a 10-ms delay. The 0000 count also changes the state of the polarity flip-flop, enabling the $+$ comparator.

After the 10-ms delay initiated by the setting of the control flip-flop, a second clear pulse starts another count. This time the $+$ comparator, because of its input from the saturated main amplifier, stops the count even before the sweep is initiated at a count of about 2800 (point E). Since this is above 2200 the range shifts up one step (point F), and a new count is initiated after a 200-ms delay (point G).

Two more measurement cycles (G to H and H to I) step the voltmeter up to its highest range, which decreases the main amplifier gain enough to bring it out of saturation. (Remember, however, that the loop gain always stays constant.) When, in the next cycle, the positive sweep reaches the value of the voltage from the main amplifier, the comparator sets the control flip-flop to "0", stopping the count at 0500 (point J). This number does not exceed the range-change values, so the print gate is enabled, and the final readout, 050.0V, appears on the indicators and at the binary-output socket. This readout is displayed until the next sampling-rate oscillator pulse occurs (point K).

It is useful to consider one more worst-case example (for the 1820-P1), namely, that in which a 50-mV input signal is applied when the voltmeter is on its highest range. Then the measurement cycle begins as it did above. However, whether the right sweep comparator is enabled or not, the count goes all the way to 0000. This happens because the next-to-last count, 000.1 V, is greater than the input voltage and much greater than the voltage supplied to the comparator by the main amplifier, which is operating at minimum gain. The first time the 0000 count is reached, the polarity latch complements the polarity flip-flop, and the count is restarted. The second time the 0000 count is reached, the polarity is not complimented because the polarity latch will not send out more than one pulse in 50 ms. The range-change circuits are then activated,

the range is stepped down, and the circuits settle down to wait for the next sampling-rate oscillator pulse. This pattern is repeated until the voltmeter arrives at its lowest range and the correct voltage readout occurs.

4.2.2 LOG OPERATION.

The log-measurement operation of the Type 1820, shown in Table 4-1, is similar to the linear operation, as far as logic processes are concerned, with two important exceptions: the polarity flip-flop is set by the FUNCTION switch so that only the $-$ sweep comparator is used, and a wrong-polarity signal does not prevent the range from changing. Instead, it enables the range-decrease gate. The ranging process for logarithmic measurements is described in paragraph 4.8.

4.2.3 RESISTANCE MEASUREMENT.

The Type 1820 Digital Voltmeter is capable of making resistance measurements with either the Type 1820-P1 or the Type 1820-P2 plug-in units. When the Type 1820-P1 is used, a floating voltage source in series with a resistance is inserted in the feedback loop to supply a constant current to the unknown resistor. When the Type 1820-P2 is used, a constant current source external to the feedback loop is employed. For a complete description of these measurements, refer to the Principles of Operation section of the instruction manual for the appropriate plug-in.

4.3 THE MAIN AMPLIFIER

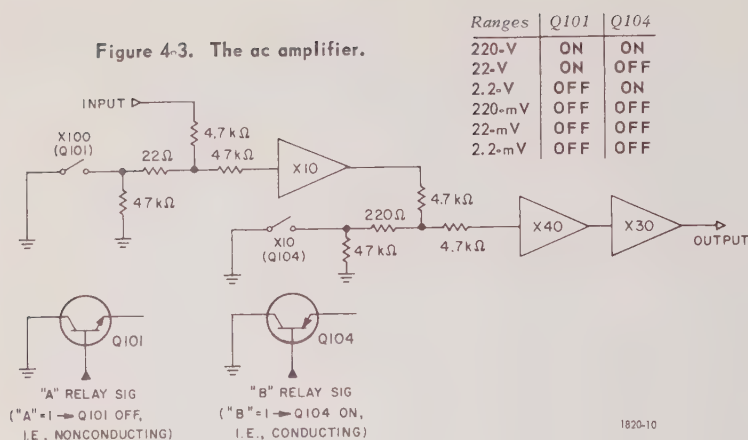
The main amplifier is comprised of five functional units: the ac amplifier section with its associated attenuators, the range-changing relay section, the demodulator, the dc amplifier, and the 300-Hz oscillator, which drives the photochopper (in the plug-in unit) and demodulator. The logic signals from the relay-driver circuits select the attenuators in the ac amplifier section and the amount of dc feedback to the preamplifier so that the loop gain of the input-preamplifier-main-amplifier section is constant regardless of range. This loop gain is approximately 80 dB. (An exception to this is the last range of the Type 1820-P2.) This amount of feedback for each voltmeter range is tabulated in Table 4-2.

The ac amplifier has five sections: the X100 attenuator (switched by Q101), the X10 amplifier (Q102 and Q103), the X10 attenuator (switched by Q104), the X40 amplifier (Q105 and Q106), and the X30 amplifier

TABLE 4-2.
Feedback Used On Each Range.

Range (V)	Relative Amount of Feedback (dB)	Loop Gain (dB)	Gain of Main and P2 Preamplifier Combination (set by range-change relays)
22 to 220	0	80 (P1 and P2)	+80
22 to 2.2	-20	80 (P1 and P2)	+100
2.2 to 220 m	-40	80 (P1 and P2)	+120
220 m to 22 m	-60	80 (P1 and P2)	+140
22 m to 2.2 m	-80	80 (P2)	+160
0 to 2.2 m	-100	60 (P2)	+160

Figure 4-3. The ac amplifier.



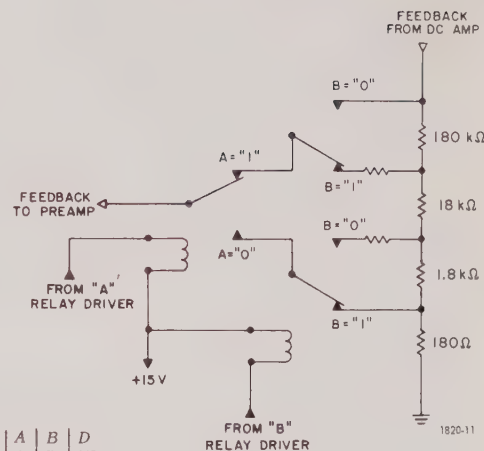
Ranges	Q101	Q104
220-V	ON	ON
22-V	ON	OFF
2.2-V	OFF	ON
220-mV	OFF	OFF
22-mV	OFF	OFF
2.2-mV	OFF	OFF

(Q107 and Q108). The attenuators are simply transistors that switch in and out voltage dividers at the amplifier inputs, as illustrated in Figure 4-3. The amplifiers are all cascaded pairs of npn transistors with negative feedback from the collector of the second to the base of the first.

The basic circuit of relays A and B is shown in Figure 4-4. The amount of feedback to the preamplifier is controlled by the same signals that fix ac amplifier gain.

The demodulator, Q109 (Figure 6-3), is driven by the 300-Hz oscillator that drives the photochoppers. The demodulation process converts the ac amplifier output to dc with an efficiency of 10% (pk-pk input to dc output).

The dc amplifier is a feedback-type miller integrator with the feedback resistor, which would be across C121, omitted. The reason for this omission is that the feedback resistor would be about 200 MΩ, which is so large that its feedback function in the closed loop is relatively negligible. The operation of the dc amplifier is as follows: A floating power supply is connected between AT126 and AT128 with the center tap at AT127, as shown in Figure 4-5. The voltage between AT126 and AT127 is 420 V (AT126 positive) and the voltage between AT127 and AT128 is about 300 V (AT127 positive). If it is first assumed that Q111 is saturated with its collector at 0 V, then Q113 and Q112 are cut off. Since diodes CR111 and CR112 fix the current through transistors Q114 and Q115 at 3.5 mA, they will quickly saturate because their load resistance is not large enough to keep them out of saturation. Therefore AT128 will be close to ground potential, and AT127, the output of the amplifier, will be at about +300 V. On the other hand, if Q111 is cut off with its collector at +15 V, Q112 and Q113 will be saturated. The potential at AT126 will then be approximately the base voltage of Q112, which is +100 V. The output voltage at AT127 will thus be approximately -320 V. Since in normal operation Q111 is neither cut off nor saturated, the output voltage will be anywhere between +300 and -300 V, depending on the input voltage. Diodes CR105 and CR106 are included to improve the amplifier overload recovery, and diodes CR120 and CR121 (shown in Figure 6-3) isolate the amplifier from its loads, the sweep



Ranges	A	B	D
220-V	1	0	0
22-V	1	1	0
2.2-V	0	0	0
220-mV	0	1	0
22-mV	0	0	1
2.2-mV	0	1	1

Figure 4-4. The range-change relays.

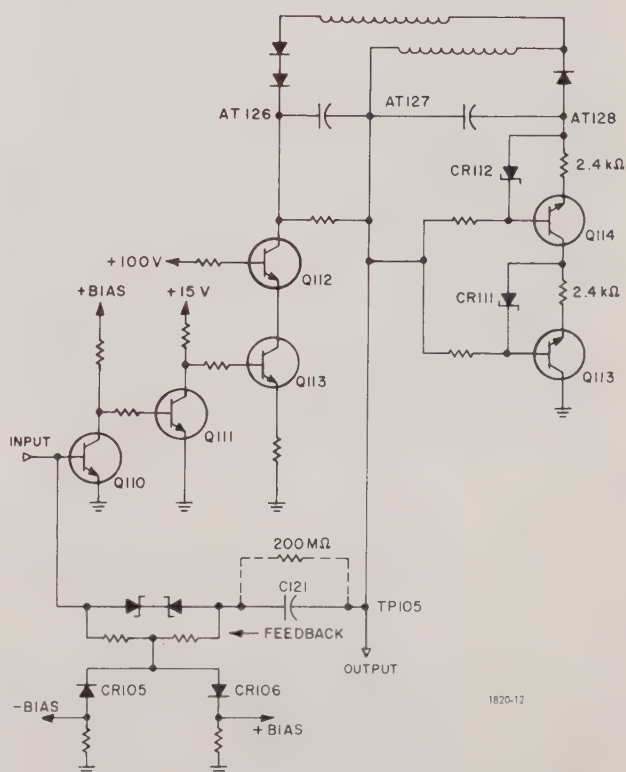


Figure 4-5. The dc amplifier.

circuits. The measurable gain of the dc amplifier is about 2000 when the feedback resistor is inserted across C121.

The over-all maximum gain of the preamplifier and main amplifier is about 160 dB (140 dB with the Type 1820-P1). This large amount of gain effectively swamps out any component-characteristic changes and makes possible the high input impedance of the voltmeter.

The 300-Hz oscillator is a symmetrical astable multivibrator, which generates square waves from 0 to +15 V. It drives the two neon-drivers, Q121 and Q122, as well as a demodulator driver, Q120. Thermistor R100 is included in the neon-driver circuit to compensate for the rather large temperature coefficient of the photo-resistors. Higher temperatures will cause the current in the neon bulbs to increase and thus emit more light to overcome the higher resistance in the photocells, and lower temperatures will cause the neon-bulb current to decrease to increase the resistance of the photocells, thus maintaining almost constant input impedance for the photochopper unit.

4.4 THE SWEEP CIRCUITS.

The sweep circuits are activated by the start-sweep flip-flop, which is activated by a negative signal from the 2393-and-counting gate. This gate consists of three transistors in series, which, when all are conducting, momentarily ground the input (base of Q335) to the start-sweep flip-flop. This sets the flip-flop to the "1" state and starts the sweeps. The three and-gate transistors will all conduct at once when:

- (1) the control flip-flop is reset (counting in progress)
- (2) the second-most significant digit is 3
- (3) the least significant digit is 3.

These events will first occur simultaneously when the count reaches 2393. (Recall that the count comes down from 2999.)

The basic sweep generators, shown in Figure 4-6, are simple RC circuits, R246 and C903 for the + sweep and R216 and C904 for the -sweep. The charge-control transistor Q334 (Q336 in the -sweep circuit) is normally off when the sweeps are in the reset condition. This allows current to flow between points A and B and between B and C, thus keeping the capacitor fully charged. During the sweep the transistor is on (conducting) and current flow from B to C is cut off. This allows the capacitor to discharge through the 207-k Ω resistor and the SLOPE resistor. The capacitor voltage tries to go from +16 to -100 V (or -16 to +100 V) but is stopped at around 0 V by the diode network.

The slope of each RC-generated sweep is logarithmic and can therefore be compared directly with the input voltage from the dc amplifier for LOG measurements. For measurements in the LINEAR mode, linearizers are required to compensate for the exponential slope of the sweep signal. These slope compensators actually operate on the signal from the dc amplifier, not on the sweep signals. The dc-amplifier signal is fed into a network of resistors and diodes which causes it to be nonlinear in exactly the same way as the sweep signals are nonlinear. The + slope compensator is always part of the + sweep comparator input, while the - slope comparator is switched in and out of the - comparator by the FUNCTION switch. The LOG function is therefore available for -dc, ac, and resistance measurements.

The comparator circuits and the comparator or-gate are shown in Figure 4-7. The comparator circuits are two back-to-back differential amplifiers, Q204-Q205 and Q208-Q209. Each of these has a shunt transistor (Q201 and Q210) across one side, which, when turned on by the appropriate polarity signal, keeps both transistors of the differential amplifier from conducting by raising their common-emitter voltage above the highest expected input signal. Basically, what the comparator does is switch the conduction of current from the left-hand transistor of the non-shunted pair

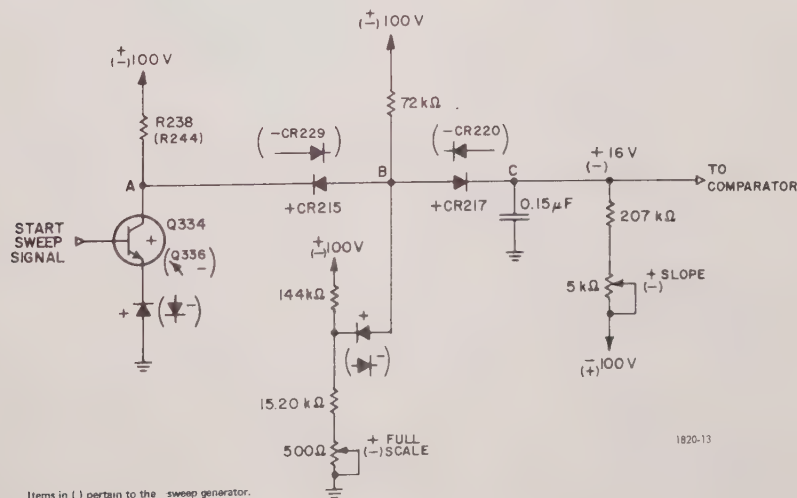


Figure 4-6. The sweep generator.

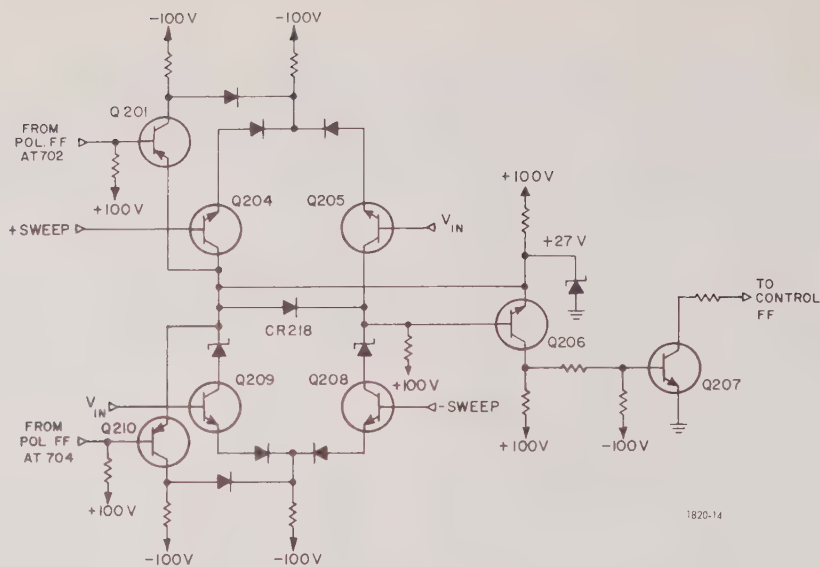


Figure 4-7. The sweep-comparator.

to the right-hand transistor whenever the input voltages are the same. This lowers the base voltage of Q206, shutting it off and thus sending a negative pulse to set the control flip-flop and stop the counter.

At the end of a counting cycle, the control flip-flop is set to its "0" state, and a positive signal from Q203 resets the start-sweep flip-flop, so that the sweep circuits can be recharged for the next cycle.

4.5 THE COUNTER

The counter in the Type 1820 consists of three decade counters and one ring-of-three counter. The counter is pulsed by the main clock, a 500-kHz crystal-controlled feedback oscillator, through the counting gate consisting of Q338 and Q339. This gate allows clock pulses to reach the counting units only when

Q338 receives a count from the control flip-flop (count or reset mode).

Each decade counter consists of an odd-even flip-flop and a ring-of-five counter. A simplified diagram of the first four digits of a typical decade counter is shown in Figure 4-8. The counting process occurs as follows:

The count is first set to 9 by the negative-going clear pulse. This pulse sets the flip-flop to the odd state and pulls down the base voltage of QX16 (X represents 3, 4, or 6) so that it conducts, thereby raising the base voltage of QX17 so that it conducts also. QX17 conducting keeps down the base voltage of QX16 after the negative pulse is removed, so the 9-8 pair stays on.

No other two-digit pair can remain on while the 9-8 pair is conducting because, with QX16 and QX17

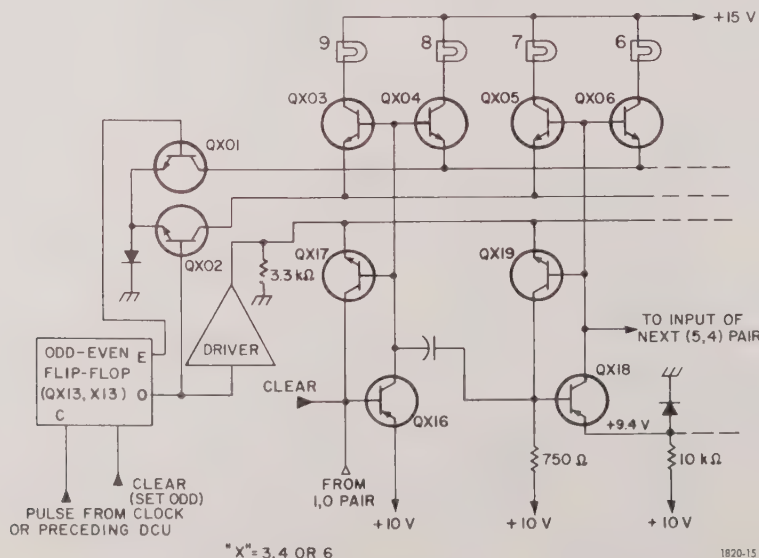


Figure 4-8. A typical Decade Counting Unit – the first four digits.

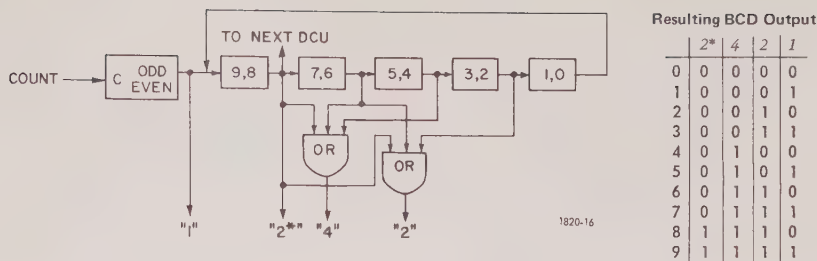


Figure 4-9. Decade Counting Unit (DCU) logic diagram.

saturated, the emitter voltage of all the odd-numbered transistors will be raised to about +9.4V, the supply voltage applied to the emitter of QX16 less the 0.6-V drop across QX16. If any other pair were conducting, the most the base voltage of the odd-numbered transistor could be is about +8.8V, as the emitter bias on the even numbers of these pairs is only +9.4V. The odd-numbered transistor, therefore, cannot remain conducting and both transistors must be off.

The first clock pulse after the counter is reset complements the flip-flop, which, in its even state, causes the "8" lamp to glow. The next clock pulse again complements the flip-flop, which enables the odd-numbered lamp circuits and causes the driver to apply a 15-V pulse to the ring of five. This pulse turns off the odd-numbered transistor of the presently-conducting pair, which raises the base voltage of the even numbered transistor and turns it off also. The collector voltage of the even-numbered transistor drops from around 9V to 0V, sending a negative pulse to the next pair. This pulse lasts longer than the inhibiting original 15-V pulse, so that the next pair is turned on by it in the same manner as the first pair is turned on by the clear pulse.

Subsequently, each time the flip-flop goes from even to odd, the ring-of-five count advances a stage—from 7-6 to 5-4 and so on, around to 1-0 and back to 9-8, at which time a pulse is sent out to the next DCU.

A number of diode gates are connected to the outputs of various digit pairs and to the flip-flop as shown in Figure 4-9. This network produces a binary-added signal corresponding to the decimal count of the DCU for application to the DATA OUTPUT socket.

The ring-of-three counter, which is physically a part of the over-ranging and polarity control circuit assembly, is set up in the same way as the decade counters, that is, with a +10-V emitter bias on the first ("2") pair and a +9.4-V bias on the remaining pairs. The count and clear or reset operations proceed in the same way, except that there is no odd-even arrangement.

4.6 THE POLARITY-CONTROL CIRCUITS

The polarity-control circuits, located on the etched board with the main-counter ring-of-three and the relay drivers (Figure 6-8), comprise the 0000 and-gate, the polarity latch, and the polarity flip-flop. Q711, the heart of the 0000 and-gate, is turned off if and only if all the signals applied to CR705 and CR706 are "1", i.e., are about +10V. These signals, consisting of two

taken from each decade counter - one from the 0-1 stage of the ring-of-five and one from the even side of the odd-even flip-flop - plus the "0" signal from the main-counter ring-of-three, momentarily raise the anode voltage of the diodes high enough to prevent current flow from the base of Q711. The negative pulse thus generated by Q711 sets the control flip-flop to stop the count and triggers the polarity latch through C701, causing Q712 and Q713 to send a positive complementing pulse to the polarity flip-flop (Q702, Q703). The polarity flip-flop activates the appropriate slope comparator and lights the corresponding indicator in the visual display. If the FUNCTION is set LINEAR and the MEASUREMENT switch is set to DC, the signal from the polarity latch also inhibits the range-change gates. This prevents a change of ranges before both polarities have been tried by the comparators.

The setting of the polarity latch discharges C701, which must be charged again before it will pass another set pulse. This recharging requires about 50 ms, during which delay a pulse from the 10-ms one-shot clears the counter and resets the logic circuits (including the polarity latch) for another sweep, this time with a different-polarity comparator enabled. If the count again reaches 0000, it will do so before the delay is over, so the polarity latch will not be triggered, the range-change gates will not be inhibited, and the next lower range will be tried. Note that the 50-ms delay is not necessary for setting the latch, only for resetting it.

If the FUNCTION switch is set to the LOG position, the polarity flip-flop is locked to enable only the - slope comparator. Also, in this case, a wrong-polarity signal from the polarity latch will help cause, not prevent, the range shift-down.

4.7 THE MEASUREMENT- AND DATA-OUTPUT-CONTROL CIRCUITS

Except for the control flip-flop circuit, which is on the sweep circuit diagram, Figure 6-3, the measurement- and data-output-control circuits and range-control circuits are shown in Figure 6-8. The former comprised a 10-ms monostable multivibrator, or one-shot, a 200-ms one-shot, a unijunction-transistor relaxation oscillator (the SRO), a 1-ms clear-pulse generator, the print-command flip-flop, and various diode gates. The over-all operation of the circuits is described in paragraph 4.2, and their functional relationships are indicated in the block diagram of Figure 6-1. The following description assumes an understanding of

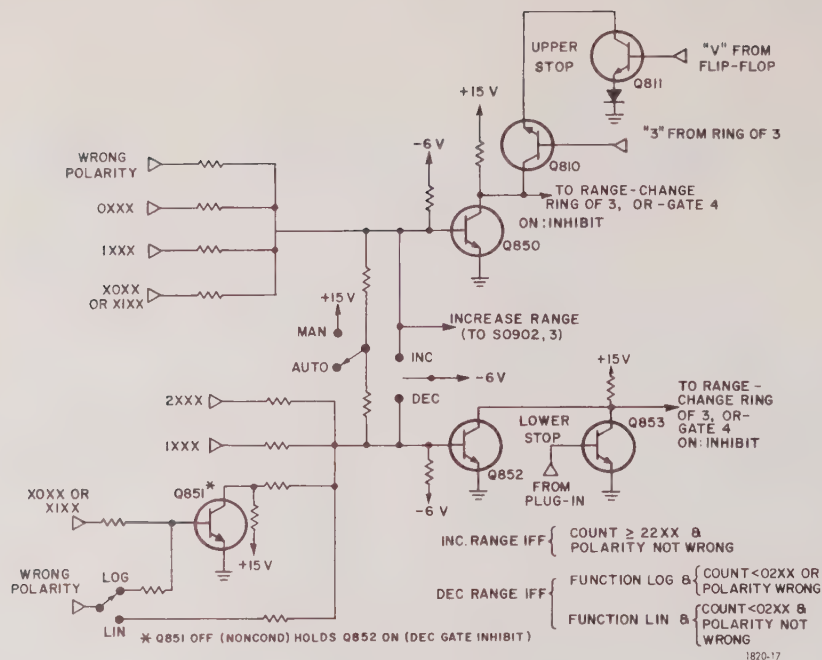


Figure 4-10. Range-gate circuitry.

flip-flops, multivibrators, and the like and is intended to be a guide to such things as signal polarity, which may not be readily apparent from the diagrams.

The control flip-flop (Q202, Q203) is set into the count of "1" state by a positive pulse derived from the trailing edge of the 1-ms clear pulse. This occurs after the counter has been reset (2999) by the main part of the clear pulse (0-V level). In the count state, one side (Q202) of the control flip-flop signals the 2393-and-counting gate, and the other side (Q203) holds the base of count gate Q338 positive, allowing the count to proceed.

A negative pulse, either from a sweep comparator or from the polarity latch, turns Q203 on and Q202 off - the "0" state of the flip-flop. As a result of this stop signal, a negative-going signal from the collector of Q202 triggers the 10-ms one-shot (Q854, Q855) into its astable state: Q854 off, Q855 on. The corresponding positive signal from Q203 resets the sweep flip-flop.

The low collector voltage of Q855 brings down the base voltage of Q856, the delay-over-and-wrong-polarity gate 1, and holds it off. This allows the positive wrong-polarity signal, if one exists, to turn on Q650 and stop the SRO timing cycle.

After 10 ms, the time allowed for the resetting of the sweep circuits, the setting of the polarity latch, and the complementing of the polarity flip-flop, the one-shot reverts to its stable state. The resulting positive-going signal at the collector of Q855: (1) triggers the 200-ms one-shot and sends a shift pulse to the range-change ring-of-three if the signal from either range-change gate is positive; (2) sets the print-command flip-flop to "1" if there is no positive signal from either range-change gate or from the polarity latch; and (3) allows Q650 to stop conducting (if it had been) if the 200-ms one-shot is not holding it on. The 200-ms delay that accompanies a range shift allows the ranging relays time to operate.

When Q650 turns off, either at the end of the 10-ms delay or at the end of the 200-ms delay, depending on whether the range was shifted, a positive pulse is applied through or-gate 3 to the clear-pulse generator. The latter consists of a 1-ms one-shot (Q652, Q653) and a driver (Q654), which sends out the clear pulse, the 0-V level of which resets the counter, polarity latch, and print-command flip-flop. The retransition to +15V after 1 ms resets the control flip-flop.

If there is no wrong-polarity signal during the 10-ms delay, and if there is no range-change signal to trigger the 200-ms one-shot, i.e., if a complete voltage measurement has been accomplished, then the timing capacitor, C651 of the SRO, will charge up to the firing point of Q651, and the resulting SRO pulse will initiate a clear pulse for a new measurement cycle.

NOTE

This instrument may be operated by external command through pin (1) of SO904. A ± 10 -V level on this line will stop the SRO, and a 0 level will let the SRO run at a rate dictated by the front-panel or external trigger.

4.8 THE RANGE-CONTROL CIRCUITS

There are three main sub-units of the range-control circuits: the range-change gates with their upper and lower stops; the range-change ring-of-three counter and volt-millivolt flip-flop, with the gates in-between; and the first digit (MSD) bulb drivers, relay drivers, and associated gates. Of these, the first two are located on the etched board with the measurement-and data-control circuits, the schematic of which is shown in Figure 6-9. The schematic diagram of the last sub-unit is shown in Figure 6-8 along with the polarity-control circuits.

4.8.1 THE RANGE-CHANGE GATES.

and the range will be decreased, as it should be in the LOG mode. In the LOG mode, there is no hysteresis in the system. A change of range will occur when the second-most-significant digit is 2 and the first digit is even.

Associated with the range-change gates are the range stops: upper stop Q810 and Q811, and lower stop Q853. The upper stop prevents a range increase when the counter is already on its highest range (XXX.X V). The lower-stop signal is supplied by the plug-in unit.

When the FUNCTION switch is set to MANUAL, a positive 15-V bias is applied to both range-change gates to hold them on. No range change will then occur unless the INCREASE/DECREASE toggle switch is held to one side to enable one of the gates with a negative 6-V bias, which overrides the +15V on that side.

4.8.2 RANGE-CHANGE RING OF THREE.

A simplified diagram of the ring-of-three counter is shown in Figure 4-11. This circuit counts either forward or backward, depending on the bias voltage applied by the range-change gates. In the simplified diagram only the count-forward condition is shown. The count-backward condition differs in that the CB signal is +15 V and the CF signal 0 V, just the reverse of the condition shown. When the range is correct, both voltages will be 0 V.

The counting process is as follows: Suppose the ring is in the "2" state (XX.XX). When the shift pulse arrives, Q804 and Q805 are conducting and all other transistors are off. The pulse turns off Q804 and Q805, causing a small positive pulse (A) at the collector of Q804, a large negative pulse (B) at the collector of Q805, and a small positive pulse (C) at the common emitters of the lower transistors (due to the discharge of C812).

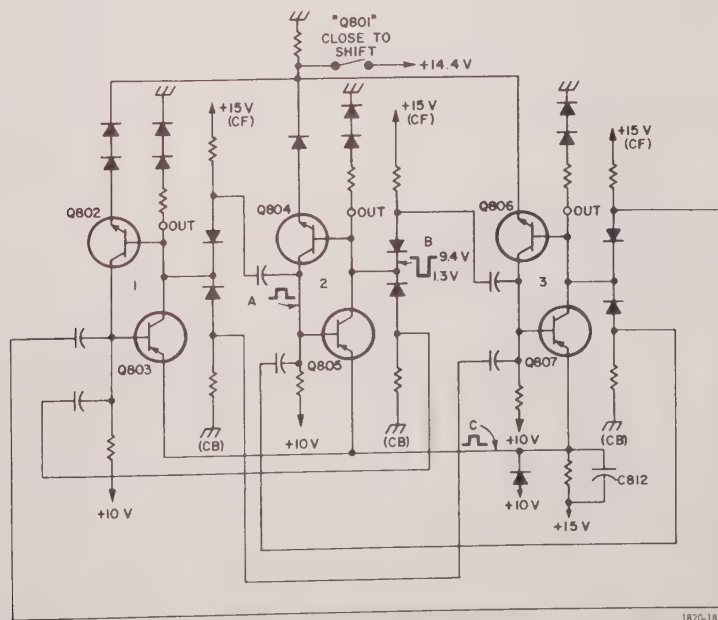


Figure 4-11. The range-change ring-of-three counter.

Pulses A and C are not sufficient to turn any transistors on as long as the shift pulse lasts. Pulse B is transmitted to the base of Q807 and causes it to conduct, raising the voltage on the base of Q806, which also conducts as soon as the shift pulse ends. All other transistors remain off. The switching of bias for the count-backward mode would allow pulse B to reach the base of Q803 instead of Q807. When both range-change lines are at ground potential, no shift pulse can occur.

4.8.3 THE RELAYS AND MSD DRIVERS.

The volt-millivolt flip-flop and the ring-of-three range counter make the six voltage ranges of the Type 1820 possible. These apply signals to the relay-driver circuits as shown in the block diagram of Figure 6-1. Note that the "1" state of the driver transistors is off (non-conducting).

The range-control circuits also control the last digit of the display when the FUNCTION switch is set to LOG. In this mode, the most significant digit (MSD) of the display takes over the logical function of the decimal-point position. When the Type 1820-P2 plug-in is used, the volt-millivolt flip-flop controls the +60-dB bulb to account for the six logarithmic ranges possible with this unit. The four ranges possible with the Type 1820-P1 correspond, as far as operation of the logic circuits is concerned, to the upper four ranges of the P2. The +60-dB bulb, however, does not glow on reception of the "1" from volt-millivolt flip-flop, and the -60-dB indication of the lowest P1 range (-14 to +2dB, displayed as 46 to 62dB) is given only by the BCD range signal at the DATA OUTPUT connector (refer to Table 3-1). Figure 4-12 illustrates the operation of the MSD-display circuitry and applies for all plug-in units.

A typical logarithmic measurement (with the Type 1820-P1 plug-in unit) proceeds as follows: An input voltage, for example, of 3.16V is applied. The counter steps itself to the appropriate range, and the logarithmic sweep voltage (see Figure 4-13) intercepts the sweep-input voltage (0.316 V) at a count of 1000. Since this is in the "2, 3, 4" range and the MSD count is 1, the "3" bulb glows and 30.00 dB is displayed.

4.9 THE POWER SUPPLY

The power supply comprises four regulated dc supplies and two unregulated floating dc supplies (see Figure 6-10). The latter supply power to the dc amplifier (from anchor terminals AT21, AT22, and AT23 through diodes CR527, CR528, and CR529) and to the 9-V floating supply in the plug-in unit via SO901 (from the bridge rectifier CR505 - CR508, which yields 170 V dc).

All the power supplies in the instrument are short-circuit proof, that is, they will not be damaged even by an extended short-circuit. Two of the regulated supplies are the +100-V and -100-V references for the voltmeter. These two supplies are the most highly regulated (0.01%) and are the only supplies that are adjustable. The other power supply tolerances are not critical and are held to $\pm 5\%$ by their reference diodes. All four regulated supplies are interdependent, that is, the 15-V supply is dependent on the -6-V sup-

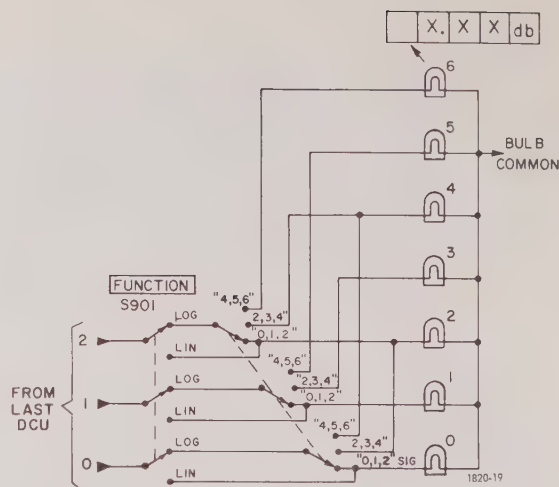


Figure 4-12. Representation diagram of the MSD and dB drivers.

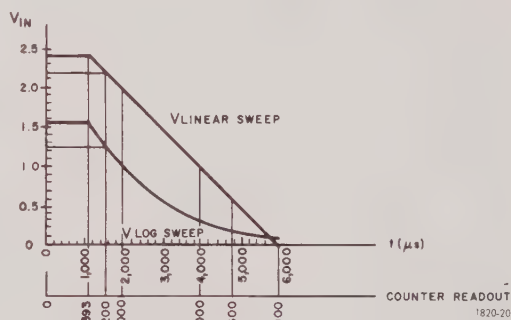


Figure 4-13.

Sweep voltage vs counter readout in LOG and LIN modes.

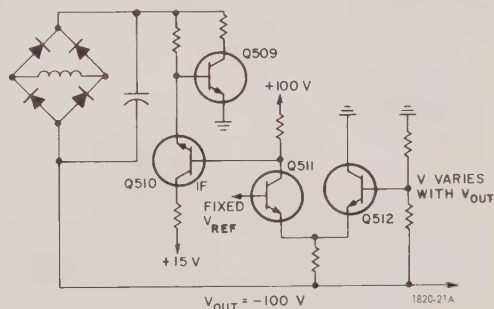


Figure 4-14a. The -100-V supply.

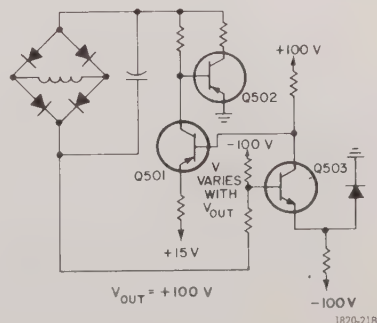


Figure 4-14b. The +100-V supply.

ply and vice versa, and the + and -100-V supplies are dependent on the 15-V supply and on each other.

The main reference supply is that one producing -100V, which is shown in a simplified version in Figure 4-14a. The regulation process occurs as follows. Suppose the output voltage differs from ideal by +10V. This raises the voltage at the base of Q512, which causes more current to flow through Q512 and less through Q511. This raises the base voltage of Q510, at the same time raising its emitter voltage, i.e., the base voltage of Q509, with the result that Q509 conducts more current from the + side of the bridge rectifier to ground. Thus the voltage of the supply is lowered with respect to ground, bringing V_{OUT} back to -100V. If the output varies in the other direction, the opposite of the above process occurs.

The +100-V supply is illustrated in Figure 4-14b so that its similarities to the -100-V supply are readily apparent. Its operation is similar to that of the -100-V supply, except that the output voltage is compared to the -100-V reference rather than to a diode reference.

The 15-V supply has a series regulator, which functions as follows (see Figure 6-10): If the voltage at the base of Q505 varies from 1V, which is the level

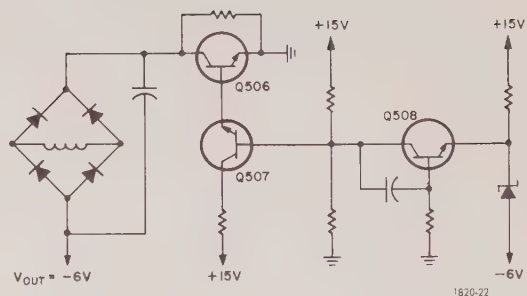


Figure 4-15. The -6-V power supply.

at that point when the +15- and -6-V supplies both have correct output voltage, Q505 will increase (or decrease) its collector current. This results in Q504's increasing (or decreasing) its collector current, which lowers (or raises) the base voltage of series transistor Q506. Q506 varies the amount of output current it supplies to bring the difference voltage between the +15- and -6-V supplies back to where it should be.

The -6-V supply has a series regulator in its ground path. It is shown in simplified form in Figure 4-15.

Service and Maintenance—Section 5

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CAUTION

Turn off power before removing or replacing etched boards.

5.1 WARRANTY

We warrant that each new instrument manufactured and sold by us is free from defects in material and workmanship, and that, properly used, it will perform in full accordance with applicable specifications for a period of two years after original shipment. Any instrument or component that is found within the two-year period not to meet these standards after examination by our factory, District Office, or authorized repair agency personnel, will be repaired or, at our option, replaced without charge, except for tubes or batteries that have given normal service.

5.2 SERVICE

The two-year warranty stated above attests the quality of materials and workmanship in our products. When difficulties do occur, our service engineers will assist in any way possible. If the difficulty cannot be eliminated by use of the following service instructions, please write or phone our Service Department (see rear cover), giving full information of the trouble and of steps taken to remedy it. Be sure to mention the serial and type numbers of the instrument.

Before returning an instrument to General Radio for service, please write to our Service Department or nearest Sales Engineering Office, requesting a "Returned Material Tag". Use of this tag will ensure proper handling and identification. For instruments not covered by the warranty, a purchase order should be forwarded to avoid unnecessary delay.

5.3 MINIMUM PERFORMANCE STANDARDS

For a quick check of basic circuit functioning, refer to paragraph 3.2, "Operational Check," in this instruction-manual section. A complete check of all the catalog specifications requires a plug-in unit, and the procedures used and their results will depend on which unit is used. The complete check-out procedure for each main-frame/plug-in combination is, therefore, included in the Service and Maintenance section of the plug-in instruction-manual section.

5.4 ACCESS TO DETAIL PARTS

5.4.1 GENERAL.

To obtain access to the detail parts of the Type 1820, remove the chassis from the cabinet as described in paragraph 2.3. The locations of etched-board assemblies, signal test points, and adjustable components are indicated in Figures 5-1 and 5-2. To tip the DCU up as shown, remove the indicator bank - press the metal clips on the top and bottom of the bank to unclip it from its etched board and pull it straight off - tip the board all the way up so that it catches, and clip the indicator bank back onto the etched board. To tip the amplifier circuit board up as shown, remove the four Phillips head screws that hold it in place, tip it up so that the holes in the brackets are over those on the main frame, and use two of the above screws to fasten it in place. The instrument can be operated with the boards in these positions for trouble analysis.

WARNING

There are high voltages present on the main-amplifier and power-supply etched boards and on the power transformer. Use caution when working with these boards exposed, to avoid personal injury.

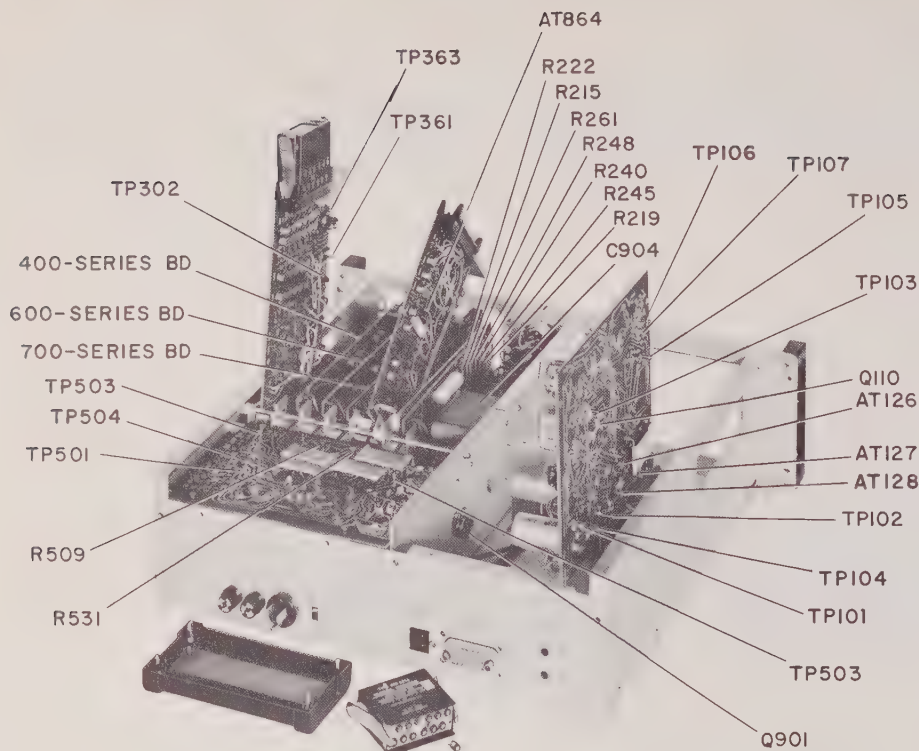


Figure 5-1.
Type 1820-A test point and component locations.

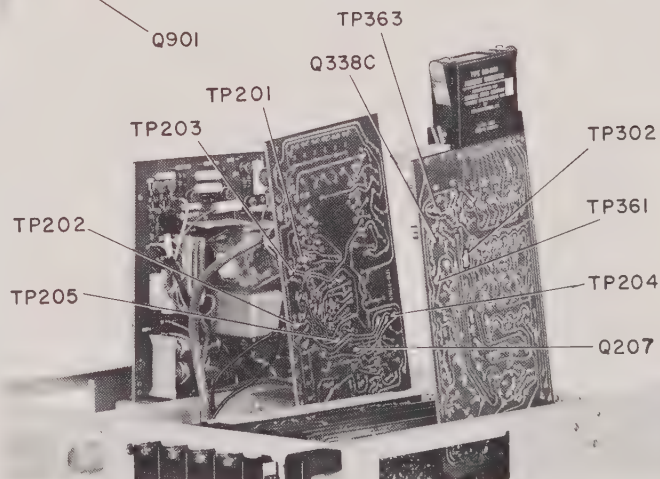


Figure 5-2.
Additional test points and components.

5.4.2 DISPLAY BULBS.

If a display bulb fails, the number it is supposed to light will remain dim. There will be no other effect on the operation of the instrument. To replace a defective bulb, proceed as follows:

- a. Pull off the bezel and display cover, which is held by four banana plugs to the front panel.
- b. Remove the indicator bank containing the defective bulb: press the metal clips on the top and bottom of the bank to unclip it from its etched board and pull the bank straight out.
- c. Pry the defective bulb out of the indicator bank with a knife blade or fingernail.
- d. Replace the defective bulb with one of the new bulbs to be found in the front panel on either side of the display. Just drop the bulb in the empty hole and press it down.
- e. Put the indicator bank back in its slot and push it back until it catches.

- f. Put the indicator cover and bezel back on.

If the problem persists after replacement of the bulb, it is possible that the bulb driver transistor has failed. In this case, turn off the power, open the instrument, remove the transistor and test it.

5.4.3 KNOB REMOVAL.

If it should be necessary to remove the knob on a front-panel control, either to replace one that has been damaged or to replace the associated control, proceed as follows:

- a. Grasp the knob firmly with the fingers, close into the panel (or the indicator dial, if applicable), and pull the knob straight away from the panel.

CAUTION

Do not pull on the dial to remove a dial/knob assembly. Always remove the knob first.

b. Observe the position of the set screw in the bushing, with respect to any panel markings (or at the full ccw position of a continuous control).

c. Release the set screw and pull the bushing off the shaft. Use a 3/32-inch Allen wrench.

d. Remove and retain the black nylon thrust washer, behind the dial/knob assembly, as appropriate.

NOTE

To separate the bushing from the knob, if for any reason they should be combined off the instrument, drive a machine tap a turn or two into bushing for a sufficient grip for easy separation.

5.4.4 KNOB INSTALLATION.

To install a snap-on knob assembly on the control shaft:

a. Place the back nylon thrust washer over the control shaft, if appropriate.

b. Mount the bushing on the shaft, using a small slotted piece of wrapping paper as a shim for adequate panel clearance.

c. Orient the set screw on the bushing with respect to the panel-marking index and lock the set screw with a 3/32-inch Allen wrench.

NOTE

Make sure that the end of the shaft does not protrude through the bushing or the knob won't set properly.

d. Place the knob on the bushing with the retention spring opposite the set screw.

e. Push the knob in until it bottoms and pull it slightly to check that the retention spring is seated in the groove in the bushing.

NOTE

If the retention spring in the knob comes loose, reinstall it in the interior notch with the small slit in the inside surface of outer wall.

5.5 REWIRING FOR 210- TO 250-V LINE

This instrument is normally wired for 195- to 235-V operation with the LINE switch in the 210- to 250-V position. To rewire for 210- to 250-V operation, remove the instrument cover and the shield over the power-supply board. Remove the four screws securing the board and swing it up, holding it in place with two screws. Move the VT wire from AT2L to AT2 on the power-supply board. Replace the board, shield, and cover. Set the LINE switch to 210-250 V for operation from this voltage.

5.6 CALIBRATION PROCEDURE

5.6.1 EQUIPMENT REQUIRED.

The equipment required to calibrate the Type 1820-A is listed in Table 5-1.

5.6.2 POWER-SUPPLY ADJUSTMENTS.

Before any adjustments are made on the Type 1820, the power supplies must be set to the correct values. There are only two supplies that can be adjusted, and these are the +100-V and -100-V supplies. Both of these supplies should be set to the nominal value to within $\pm 0.05\%$ accuracy.

TABLE 5-1
Test Equipment *

<i>Device</i>	<i>Necessary Specifications</i>	<i>Recommended Type</i>
1 { Plug-in preamplifier	No substitution.	GR 1820-P1 DC Multimeter/UHF Voltmeter or GR 1820-P2 AC/DC Millivoltmeter
{ ± 200 -V dc reference supply	Accuracy - $\pm 0.05\%$	Fluke Precision Voltage Calibrator Model 332A
{ Decade divider	100-k Ω impedance, $\pm 0.05\%$ accuracy	GR 1454-AH Decade Voltage Divider
2 { Vacuum-tube voltmeter (VTVM)	20,000- Ω /V input impedance	GR 1806 Electronic Voltmeter
{ Cathode-ray oscilloscope (CRO)	Calibrated sweep, calibrated vertical gain, external sync capability	Any
{ Capacitor	About 0.01- μ F	Any

1 For calibration

2 For trouble analysis

* Or equivalent

Adjust the -100-V supply first, because this adjustment (R531) will affect the +100-V adjustment (R509). After both supplies are adjusted, go back and recheck.

The following procedure describes how to check sweep alignment for the dc function of the voltmeter. The alignments of the ac, k Ω , and M Ω functions are plug-in adjustments.

5.6.3 ADJUSTMENTS OF SWEEP CIRCUITS.

This step requires a stable +200-V supply, a means of measuring it, and a 100-k Ω decade divider. The procedure for the adjustment of the positive sweep is as follows:

a. Apply +200.00 $\pm$ 0.05 V to the input of the instrument and adjust R240, so that the digital voltmeter reads +200.0 V. (R240 is the plus-full-scale adjustment.)

b. Using the decade voltage divider, apply +100 V to the input of the voltmeter. If the voltmeter does not read +100.0 V, adjust R245 (this is the positive slope control) so that the voltmeter reads +100 V. This adjustment affects the full-scale adjustment mentioned in step a; therefore, it is necessary to go back and readjust the full-scale control and readjust the slope control. The correct adjustment is reached when the +200 V and the +100 V are displayed correctly.

c. Set the RANGE switch to MANUAL. Apply a positive voltage from +200 V to +20 V on the 200-V range and check the accuracy of the instrument. Any nonlinearity towards the end of the range can be corrected with the positive linearity adjustment, R223. This may affect the slope adjustment; therefore, it is necessary to recheck the entire range.

Now using a negative 200-V supply and the same voltage divider, adjust the negative sweep. The adjustment is identical to the adjustments of the positive sweep, except that the following controls are used:

R248 is the negative full-scale adjustment,
R217 is the negative slope adjustment, and
R215 is the negative linearity adjustment.

5.6.4 LOG ADJUSTMENT

The dB scale has similar adjustments. It is important to note that only ac and negative dc voltage can be used with the dB scale. The maximum limit of the dB range is +62 dB with respect to 100 mV (with P1), or about 130 V.

R261 is the full-scale dB adjustment; adjust it to obtain a display of 20.00 dB for a -1.000-V input.

R219 is the dB slope adjustment; adjust it to obtain 06.02 dB for a -0.200-V input.

R222 is the dB linearity adjustment; adjust it to obtain 01.58 dB for -0.120-V input.

These adjustments all interact. Conversion from voltages to dB can be made with the use of Table 5-2.

It is important to note that on the linear ranges a range increase occurs when the first digit is two and the second digit is two or higher. A range decrease occurs when the first digit is zero and the second digit

is lower than two. Therefore, there is a region of hysteresis in linear range switching. For the dB scale, however, the range switching occurs when the second most significant digit is two and the first digit is even, for example: 02.00 dB, 22.00 dB, and 42.00 dB. There is no hysteresis for dB range switching.

This completes the alignment of the Type 1820 main frame. Refer to the maintenance section of each plug-in unit for its own alignment procedure.

5.7 TROUBLE ANALYSIS

5.7.1 GENERAL.

Most of the failures that might occur in the digital voltmeter can be isolated to a particular circuit assembly within the main frame or plug-in unit by a logical consideration of the external behavior of the instrument - the digital display, the BCD output, switch settings, etc. Table 5-3 is a summary of conclusions that can be drawn from these various aspects of instrument behavior. Once a fault has been somewhat localized by external data, the cover can be removed from the instrument and individual component replacement or adjustment can be made on the etched-board assemblies.

In addition to the following trouble-shooting information the theory section and the schematics section of this manual will prove useful. In particular, the operating voltages indicated on the schematics for the conditions noted should be referred to for comparison with those of the malfunctioning instrument. These voltages are all nominal, that is, accurate to about $\pm$ 10%. In any case it is a good idea to check out all power-supply voltages before carrying the investigation to other circuit boards.

TABLE 5-2.
Conversion of LIN to LOG Readout
for the Type 1820-P1 Plug-In.

LIN Voltage	LOG Voltage
100.00	60.00
90.00	59.08
80.00	58.06
70.00	56.90
60.00	55.56
50.00	53.98
40.00	52.04
30.00	49.54
20.00	46.02
19.00	45.57
18.00	45.11
17.00	44.61
16.00	44.08
15.00	43.52
14.00	42.92
13.00	42.28
12.00	41.58
11.00	40.83
10.00	40.00

TABLE 5-3.
Trouble Analysis - External Symptoms

<i>Digital Display</i>	<i>Operating Conditions</i>	<i>Possible Difficulties</i>	<i>Comments</i>
Nothing lights.	Instrument plugged in, POWER on.	The fuses have blown, or the power supply is inoperative, or, probably, both.	Check the fuses, the line voltage, and the power supply voltages, the latter according to the values given on schematic diagram, Figure 6-10.
Only the decimal point lights.	Same as above. Make sure rate control is not on HOLD.	The clear-pulse driver, or the 1-ms one-shot, or the sampling-rate oscillator has failed, or the 200-ms one-shot is stuck.	Refer to paragraph 5.7.5.
The last digit flickers or is very unstable (all digits unstable in extreme case).	Instrument plugged in, POWER on, SAMPLING RATE control centered, Input terminals shorted.	1) The glass rods are not firmly against the neon bulbs or photoresistors in the plug-in photochopper. 2) Reference-voltage regulation in the main supplies has gone bad.	1) Try a different plug-in. 2) Highly inaccurate readings on all ranges is also a symptom of this.
Display dim.	Same as above.	The 15-V supply is defective.	Refer to paragraph 5.7.8.
One digit does not light.	Any.	The bulb for that digit has failed.	Refer to paragraph 5.4.2.
All measurement operations are performed correctly, but the display never reads +.	Any.	The bulb has failed.	Same as above.
Two digits in an indicator light simultaneously.	Any.	The associated decimal counting unit is not functioning properly.	Refer to paragraph 5.7.4.
The counter display is correct, but no print-out occurs.	Any.	The print FF or print AND gate has failed.	Refer to paragraph 5.7.6.
P1 plug-in only: Ac zero unobtainable, Ω measurements impossible, dc measurements ok.	Any. Input shorted.	CR201 (in the P1 9-V floating supply) has failed.	Try a different plug-in.
Ac display remains 0000. Dc measurements ok.	MEASUREMENT switch set to AC. Ac and dc test signals applied to input.	The rectifier in the plug-in unit has failed.	Try a different plug-in.
<u>0000</u> 1) On all ranges.	Small dc voltage applied, MAN INC/DEC switches used to step through ranges. Same as above.		
2) Range won't change and no print-out.		Control FF is stuck in the "0" state, or the comparator OR gate has failed.	Refer to paragraph 5.7.6.
3) With a polarity sign opposite to that of the applied signal. a) Always the same polarity, e.g., +0000, when a negative signal applied (displays correctly positive voltages). b) Correct voltage displayed occasionally, but 0000 with polarity opposite to that applied often occurs.	Small dc voltage applied, first positive then negative Same as above.	1) The polarity FF is stuck, or the polarity latch is stuck in the "Right polarity" state, or the 0000 AND gate is malfunctioning. 2) The polarity latch is stuck in the "wrong polarity" state, or the 0000 AND gate is malfunctioning.	Refer to paragraph 5.7.5. Same as above.

Table 5-3 continued on next page.

>2700 TEST 1 1) All ranges ok (displays all possible decimal point and V-mV combinations). 2) Displays correct voltage on some upper range(s), print-out does occur. 3) Range will not change, and print-out does not occur. TEST 2 1) Display drifts up to +28XX. 2) Display immediately reads sometimes +28XX and sometimes -28XX. TEST 3 1) Display always reads +28XX in LIN mode, displays correct level in LOG mode. 2) Display always reads -28XX. 2999 Display stuck on one range (reads correctly for inputs within that range, but 0000 or 28XX for other inputs). No print-out occurs. Voltage not read properly on all ranges. E.g., 2.000 V correct reading on one range, but 02.00 V not read on next range. Counter ranging is erratic when a high sampling rate is used. ±Dc voltage readings out of spec, same error on all ranges. +Dc voltage readings out of spec. -Dc voltage readings out of spec. dB function out of spec with -dc voltage input (-dc linear readings ok). X 100 attenuators, resistance, current, or ac voltage readings, out of spec.	Input shorted, or small voltage applied. 5-V dc voltage applied, MAN INC/DEC switches used to step through ranges. POWER turned on and off several times with the SAMPLING RATE control centered, input terminals shorted. Small negative dc voltage applied, FUNCTION switch set to LIN then LOG; POWER turned on and off for each function. Input shorted Voltage that falls within displayed range applied, then varied with range, then varied to lie outside the range. +0.200 V applied, then +2.000 V, then 20.00 V. Use MAN INC/DEC switches to step through ranges. SAMPLING RATE control set fully clockwise, RANGE switch set to AUTO, input voltage varied by factors of ten. MEASUREMENT switch set to DC, known dc voltages applied. Same as above. Same as above. Same as above.	2) Auto-ranging circuits not working. 3) the control FF is stuck in the "0" state. 1) Main amplifier or plug-in unit defective. 2) Control or sweep circuit failures, probably the comparator OR gate. 1) + sweep generator or + comparator is defective; - sweep circuits are ok. 2) - sweep generator or comparator is defective; + sweep circuits are ok. The control FF is stuck in the "1" state, or the 500-kHz oscillator has stopped, or the comparator OR gate has failed. No shift pulse. Q801, or the 10-ms one-shot, or AND gate 2 has failed, or the range-change ring-of-three has stuck. Range-change relays stuck, or one or more relay drivers (Q715, Q720 - Q722) has failed. 200-ms one-shot is not timing properly. Main reference power supplies need adjustment. + sweep needs calibration. - sweep needs calibration. Log sweep needs adjustment. Plug-in unit needs calibration.	All range-change circuits work. Proceed to TEST 2. Refer to paragraph 5.7.7. Refer to paragraph 5.7.6. Try a different plug-in. If difficulty persists refer to paragraph 5.7.2. Refer to paragraph 5.7.3. Refer to paragraph 5.7.3. Refer to paragraph 5.7.3. Refer to paragraphs 5.7.6 and 5.7.7. Refer to paragraph 5.7.7. Refer to paragraph 5.7.6. Refer to paragraph 5.6.2. Refer to paragraph 5.6.3. Refer to paragraph 5.6.3. Refer to paragraph 5.6.4. Refer to the maintenance section of the plug-in unit instruction manual.
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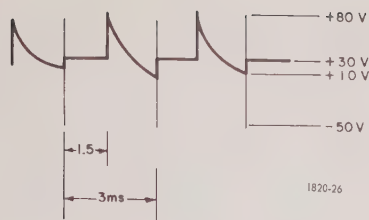


Figure 5-3. Neon-drive waveform, TP106 and TP107 (similar waveforms, 180° out of phase).

5.7.2 THE MAIN AMPLIFIER.

If the amplifier fails to operate properly, remove Q110 and test it before proceeding with the following troubleshooting procedure.

a. To pinpoint a fault in the amplifier circuits, open up the feedback loop by grounding (with a short cliplead) AT104 on the Type 1820-P1 or AT224 on the Type 1820-P2. This removes the feedback from the photochopper.

b. Make sure that the plug-in unit in use is not the source of the difficulty by applying about 4 V dc to the input terminals and observing the signal at test point TP101 on the main-amplifier board. This signal should be a 300-Hz square wave with rounded corners. If no signal is present or if the signal is nothing like a square wave, check the neon drive signals at TP106 and TP107. If the waveform shown in Figure 5-3 is present at both terminals, the fault is certainly in the plug-in unit. If this is the case, refer to the maintenance section of the instruction manual of the plug-in for further trouble-shooting procedures. If the neon-drive signal is faulty, check the "YE" cable and neon-bulb continuity with an ohmmeter, then remove and test Q118 through Q122.

c. Check for the presence of an amplified, modulated signal at the collector of Q108. If it is not present, trace the signal through the ac amplifier at the collectors of Q102, Q103, and Q105 through Q108 to find the faulty component.

d. Observe the signal at TP103 to be a dc voltage with a small amount of 300-Hz ripple. If it is not, remove and test Q109 and Q120.

e. If all the preceding circuits and Q110 have been satisfactorily checked out, the trouble must be in the dc amplifier.

f. Table 5-4 is a compilation of output voltages from a properly functioning amplifier, with the feedback to the photochopper applied. Agreement with this table verifies that the relays and voltage dividers on the amplifier board work properly.

5.7.3 THE SWEEP CIRCUITS.

The sweeps will step whenever a pulse is produced by the + or - comparator circuits. It is possible not to have any sweep at all even though the sweep circuits are both functional. This will occur when the input amplifier is not operating properly and the comparator circuits are overloaded as a result. The DVM will read 28XX in this case. Before proceeding, therefore, check the operation of the amplifier according to paragraph 5.7.2, step f.

To observe the sweep voltages:

a. Set the FUNCTION switch to LINEAR, the RANGE to MAN, and the SAMPLING RATE control fully clockwise. Short the input terminals.

b. Synchronize an oscilloscope to the negative-going transition of the control flip-flop (TP361).

c. The + sweep occurs at TP201 and the - sweep at TP203. Look for approximately triangular signals, 16 V pk-pk, at about 30 Hz.

d. If no such signals appear, remove Q207 to isolate the control flip-flop from the comparators.

TABLE 5-4

Amplifier Outputs for Inputs on All Ranges*				
Range F.S.	Input	TP105	TP204	TP202
200.0 V	0	0	+0.9 V	-0.9 V
200.0 V	+200.0 V	+200.0 V	+15.0 V	-0.9 V
200.0 V	-200.0 V	-200.0 V	+0.9 V	-15.0 V
20.00 V	0	0	+0.9 V	-0.9 V
20.00 V	+20.00 V	+200.0 V	+15.0 V	-0.9 V
20.00 V	-20.00 V	-200.0 V	+0.9 V	-15.0 V
2.000 V	0	0	+0.9 V	-0.9 V
2.000 V	+2.000 V	+200.0 V	+15.0 V	-0.9 V
2.000 V	-2.000 V	-200.0 V	+0.9 V	-15.0 V
200.0 mV	0	0	+0.9 V	-0.9 V
200.0 mV	+200.0 mV	+200.0 V	+15.0 V	-0.9 V
200.0 mV	-200.0 mV	-200.0 V	+0.9 V	-15.0 V

* With INPUT to PLUG-IN shorted, TP105 should be at 0V for all ranges.

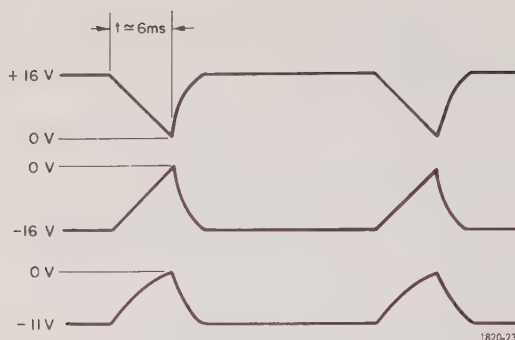


Figure 5-4.

The positive sweep (top), negative LIN sweep (middle), and negative LOG sweep (bottom).

e. If the sweeps now appear and resemble Figure 5-4, the difficulty is in the comparator circuits, if the amplifier is ok.

f. If the sweeps do not appear, skip to "SWEEPS".

g. With a VTVM, observe that the voltages in the comparator agree with those in Table 5-5, under the following conditions:

Input shorted

Small capacitor connected from TP363 to ground (stops 500-kHz oscillator)

RANGE = MAN

FUNCTION = LOG

Q207 removed

SAMPLING RATE control set to HOLD when display is -2999, then set FUNCTION to LIN

h. Check Q207 in a transistor tester. If it is ok, put it back in the comparator circuit. Remove the capacitor from TP363.

SWEEPS. If neither the + nor the - sweep occurs with Q207 removed, the difficulty is probably with the 2393 gate or the start-sweep flip-flop. With the oscilloscope still synchronized by the negative signal from the control flip-flop, look at TP362 for the start-sweep signal, negative rectangular pulses with about 6-ms duration, recurring at the sampling rate. If these pulses are absent, check the input signals to the start-sweep flip-flop from the transistors of the 2393 gate. If they are present, the problem is probably a broken connection between the flip-flop and the comparators.

TABLE 5-5
Sweep Comparator Voltages.

Test Point	V dc, Nominal
Q206E	+27
Q209B	0
Q205B	0
Q204B	+16
Q208B	-16
Q201B	+26
Q210B	+28
Q206B	+26.5

5.7.4 THE COUNTER.

a. With an oscilloscope observe the signal at TP363. A 500-kHz, roughly 30-V pk-pk signal with clipped negative peaks should be present.

b. Connect a small capacitor from TP363 to ground. The display should read 2999. If it doesn't, the clear pulse is not resetting the counters or there is no clear pulse, in which case refer to paragraph 5.7.5. Remove the capacitor.

c. With a short cliplead connect the collector of Q338 to ground so that pulses are always transmitted. Observe the signal successively at test points TP302, TP402, TP602, and TP702. The 500-kHz signal will be divided by ten at each successive point, except at TP202, where it will be divided by three.

d. Once a malfunction has been localized to a single decimal counting unit, the fault can be pinpointed by isolating that unit from the others and stepping it through its count cycle with single +10-V, 1-μs pulses.

5.7.5 THE POLARITY-CONTROL CIRCUITS.

a. Short the input terminals, and when 0000 is displayed, set the SAMPLING RATE control to HOLD. Measure the dc voltage at the base of Q711 with a VTVM. This voltage should be about +9 V. If it is not, measure the voltages at AT714, AT736, AT738, AT737, and at the collector of Q710. If all these are between +9 and +10 V, then CR705 or CR706 may be defective.

b. If the 0000 and-gate is ok, as checked in step a, the voltage at AT739 should be 0 V. If it is not, test Q711 and, if necessary, C710.

c. Measure the dc voltage at AT706. If it is not at least +14 V, remove and test the polarity-latch transistors Q709 and Q710.

d. Set the SAMPLING RATE control fully clockwise, synchronize an oscilloscope to the negative going transition at TP361, and observe the signal at TP701. With the input shorted and the FUNCTION switch on LIN, the signal should be a rectangular wave alternating between 0 V and +9 V at the sampling-rate frequency. If this signal is not present, and the complementing signal at TP706 is, then the suspect components are Q702 and Q703.

5.7.6 THE MEASUREMENT- AND DATA-OUTPUT-CONTROL CIRCUITS.

Measurement Control

a. If it is suspected that the control flip-flop is not functioning, set the SAMPLING RATE control fully clockwise, short the input terminals, set the FUNCTION switch to LIN, and observe the signal at TP361. This should be a 10-V pk-pk negative rectangular waveform about 6 ms in duration. If it is not present, look for the clear and wrong-polarity set pulses at the base of Q203. If the proper signals exist at the base of Q203, then Q202 or Q203 may be defective. If the base of

b. If the base of Q203 stays always at ground potential, Q207 is shorted or the sweep-comparator circuits are malfunctioning. Refer to paragraph 5.7.3.

c. If the wrong-polarity pulse does not appear, refer to paragraph 5.7.5.

d. If the clear pulses do not appear, observe the signal at either B1 or B2 of Q651 with the oscilloscope. If pulses are present here, the difficulty is with the clear-pulse shaper, a 1-ms one-shot, or driver Q654, or with the diodes of gate 3.

e. If the SRO does not oscillate, disconnect the wire at AT653. If the SRO still doesn't oscillate, test Q650 and Q651. If it does, the problem is on the 800-series board.

f. The 200-ms one-shot is a conventional astable multivibrator. When the base of Q857 is positively pulsed, Q858 should begin conducting for 200 ms, holding the voltage at AT866 to about 13 V. After 200 ms this voltage should drop to 0. If the one-shot gets stuck in the astable state the SRO will not work.

g. The triggering pulse for the 200-ms one-shot comes from the 10-ms one-shot, provided the range is either increasing or decreasing, that is, if the voltage at the anode of CR859 is greater than around +10 V. The 10-ms one-shot also opens gate 1 by turning off Q856. The one-shot should be set into its astable state (Q854 off, Q855 on) by a negative pulse applied to the base of Q854.

Data-Output Control

If the voltmeter is displaying correctly but not printing out, short the input terminals, set the SAMPLING RATE control fully counterclockwise, and monitor the signal at AT867 with an oscilloscope. If a negative 10-V 15-ms pulse does not appear, look for a brief positive pulse, about 10-V, at the base of Q860. If it is present, test Q860 and Q859; if not, test CR867, CR861, and CR862, assuming that the 10-ms one-shot is working.

5.7.7 RANGING CIRCUITRY.

If the instrument changes ranges in the MANUAL mode but not in the AUTO mode, the problem is in the information the range gates receive. If no ranging at all is possible, the trouble is probably lack of a shift pulse or malfunction of the range gates or upper or lower stop. In the former case, check the range-gate input by manually setting the range to 2.200 V full scale and applying successively 2.000, 1.000, 0.100,

0.000 volts. This should produce 10-V signals respectively at AT861, AT850, AT852, and AT851. If any signal is missing, check the corresponding decade counting unit according to paragraph 5.7.4.

If no ranging is possible, set the RANGE switch to AUTO and measure the dc voltage at the collector of Q850 with a voltage applied to the input terminals that exceeds the range displayed and at the collectors of Q852 and Q853 with the input terminals shorted. These voltages should be +15 V, provided the instrument is not on an extreme high or low range. If these voltages are not present, remove and test the associated transistors; if they are present, the range-change gates are ok.

Apply to the input terminals a voltage that should cause the range to change. Set the RANGE switch to AUTO and the SAMPLING RATE control fully clockwise. Look at the signal at the emitter of Q801. The shift pulse, a brief, positive, 10-V pulse, should recur here. If it does not, check the base of Q801 for the presence of a positive pulse. If there is none, refer to paragraph 5.7.6. If there is, test Q801 in a transistor tester.

If the shift pulse occurs and the range gates function properly but the range does not change, the trouble is in the range-change ring-of-three counter. The best procedure in this case would be to refer to paragraph 4.8.2 to see how the counter should work, then to apply shift pulses by appropriate operation of the MAN RANGE switch. By observing which pulses are present and which are not, the operator can determine which stage of the counter is at fault.

Trouble shooting the relay drivers of the V-mV flip-flop is simply a matter of tracing the signal through to the malfunctioning stage and testing the components in that stage.

5.7.8 THE POWER SUPPLY.

a. Measure the dc voltages at TP502, TP503, TP504, and TP501 to be as specified on the power-supply schematic diagram, Figure 6-10.

b. If the + or -100-V supply is out of tolerance, adjust it according to the directions in paragraph 5.6.3.

c. If it is impossible to adjust a reference supply, or if any of the other supply voltages are incorrect, determine where the difficulty lies by measuring whether the voltages at the various points within the regulator circuits agree with those given on the schematic diagram.

Parts Lists and Diagrams—Section 6

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FEDERAL MANUFACTURERS CODE

From Federal Supply Code for Manufacturers Cataloging Handbooks H4-1
(Name to Code) and H4-2 (Code to Name) as supplemented through June, 1967.

Code	Manufacturers Name and Address	Code	Manufacturers Name and Address	Code	Manufacturers Name and Address
00192	Jones Mfg. Co., Chicago, Illinois	53021	Sangamo Electric Co., Springfield, Ill. 62705	83033	Meissner Mfg., Div. of Maguire Industries, Inc. Mount Carmel, Illinois
00194	Walsco Electronics Corp., Los Angeles, Calif.	54294	Shallcross Mfg. Co., Selma, N. C.	80431	Air Filter Corp., Milwaukee, Wisc. 53218
00656	Aerovox Corp., New Bedford, Mass.	54715	Shure Brothers, Inc., Evanston, Ill.	80583	Hammarlund Co. Inc., New York, N. Y.
01009	Alden Products Co., Brockton, Mass.	56289	Sprague Electric Co., N. Adams, Mass.	80740	Beckman Instruments, Inc., Fullerton, Calif.
01121	Allen-Bradley, Co., Milwaukee, Wisc.	59730	Thomas and Betts Co., Elizabeth, N. J. 07207	81073	Grayhill Inc., LaGrange, Ill. 60525
01295	Texas Instruments, Inc., Dallas, Texas	59875	TRW Inc. (Accessories Div.), Cleveland, Ohio	81143	Isolantite Mfg. Corp., Stirling, N. J. 07980
02144	Ferroxcube Corp. of America, Saugerties, N. Y. 12477	60399	Torrington Mfg. Co., Torrington, Conn.	81349	Military Specifications
02606	Fenwal Lab. Inc., Morton Grove, Ill.	61637	Union Carbide Corp., New York, N. Y. 10017	81350	Joint Army-Navy Specifications
02660	Amphenol Electronics Corp., Broadview, Ill.	61864	United-Carr Fastener Corp., Boston, Mass.	81751	Columbus Electronics Corp., Yonkers, N. Y.
02768	Fastex Division of Ill. Tool Works, Des Plaines, Ill. 60016	63060	Victoreen Instrument Co., Inc., Cleveland, Ohio	81831	Filton Co., Flushing, L. I., N. Y.
03508	G. E. Semiconductor Products Dept., Syracuse, N. Y. 13201	63743	Ward Leonard Electric Co., Mt. Vernon, N. Y.	81860	Barry Controls Div. of Barry Wright Corp., Watertown, Mass.
03636	Grayburne, Yonkers, N. Y. 10701	65083	Westinghouse (Lamp Div), Bloomfield, N. J.	82219	Sylvania Electric Products, Inc., (Electronic Tube Div.), Emporium, Penn.
03888	Pyrofilm Resistor Co., Cedar Knolls, N. J.	65092	Weston Instruments, Weston-Newark, Newark, N. J.	82273	Indiana Pattern and Model Works, LaPort, Ind.
03911	Clairex Corp., New York, N. Y. 10001	70485	Atlantic-India Rubber Works, Inc., Chicago, Ill. 60607	82389	Switchcraft Inc., Chicago, Ill. 60630
04009	Arrow, Hart and Hegeman Electric Co., Hartford, Conn. 06106	70563	Amperite Co., Union City, N. J. 07087	82647	Metals and Controls Inc., Attleboro, Mass.
04713	Motorola Semi-Conductor Product, Phoenix, Ariz. 85008	70903	Belden Mfg. Co., Chicago, Ill. 60644	82807	Milwaukee Resistor Co., Milwaukee, Wisc.
05170	Engineered Electronics Co., Inc., Santa Ana, Calif. 92702	71126	Bronson, Homer D., Co., Beacon Falls, Conn.	83058	Carr Fastener Co., Cambridge, Mass.
05624	Barber-Colman Co., Rockford, Ill. 61101	71294	Cantfield, H. O. Co., Clifton Forge, Va. 24422	83186	Victory Engineering Corp (IVECO), Springfield, N. J. 07081
05820	Wakefield Eng., Inc., Wakefield, Mass. 01880	71400	Bussman Mfg. Div. of McGraw Edison Co., St. Louis, Mo.	83361	Bearing Specialty Co., San Francisco, Calif.
07127	Eagle Signal Div. of E. W. Bliss Co., Baraboo, Wisc.	71590	Centralab, Inc., Milwaukee, Wisc. 53212	83587	Solar Electric Corp., Warren, Penn.
07261	Avnet Corp., Culver City, Calif. 90230	71666	Continental Carbon Co., Inc., New York, N. Y.	83740	Union Carbide Corp., New York, N. Y. 10017
07263	Fairchild Camera and Instrument Corp., Mountain View, Calif.	71707	Coro Coil Co. Inc., Providence, R. I.	84411	TRW Capacitor Div., Ogallala, Nebr.
07387	Birtcher Corp., No. Los Angeles, Calif.	71785	Chicago Miniature Lamp Works, Chicago, Ill.	84835	Lehigh Metal Products Corp., Cambridge, Mass. 02140
07595	American Semiconductor Corp., Arlington Heights, Ill. 60004	71823	Cinch Mfg. Co. and Howard B. Jones Div., Chicago, Ill. 60624	84971	TA Mfg. Corp., Los Angeles, Calif.
07828	Bodine Corp., Bridgeport, Conn. 06605	72136	Darnell Corp., Ltd., Downey, Calif. 90241	86577	Precision Metal Products of Malden Inc., Stoneham, Mass. 02180
07829	Bodine Electric Co., Chicago, Ill. 60618	72259	Electro Motive Mfg. Co., Willington, Conn.	86684	RCA (Electrical Component and Devices) Harrison, N. J.
07910	Continental Device Corp., Hawthorne, Calif.	72619	Nytronics Inc., Berkeley Heights, N. J. 07922	86800	Continental Electronics Corp., Brooklyn, N.Y. 11222
07983	State Labs Inc., N. Y., N. Y. 10003	72699	Dialight Co., Brooklyn, N. Y. 11237	88140	Outler-Hammer Inc., Lincoln, Ill.
07999	Amphenol Corp., Borg Inst. Div., Delavan, Wisc. 53115	72765	General Instrument Corp., Capacitor Div., Newark, N. J. 07104	88219	Gould Nat. Batteries Inc., Trenton, N. J.
08730	Vemaline Prod. Co., Franklin Lakes, N. J.	72765	Drake Mfg. Co., Chicago, Ill. 60656	88419	Cornell Dubilier Electric Corp., Fuquay-Varina, N. C.
09213	General Electric Semiconductor, Buffalo, N. Y.	72825	Hugh H. Eby, Inc., Philadelphia, Penn. 19144	88627	K and G Mfg. Co., New York, N. Y.
09408	Star-Tronics Inc., Georgetown, Mass. 01830	72962	Elastic Stop Nut Corp., Union, N. J. 07083	89482	Holtzer Cabot Corp., Boston, Mass.
09823	Burgess Battery Co., Freeport, Ill.	72982	Erie Technological Products Inc., Erie, Penn.	89665	United Transformer Co., Chicago, Ill.
09922	Burndy Corp., Norwalk, Conn. 06852	73138	Beckman, Inc., Fullerton, Calif. 92634	90201	Mallory Capacitor Co., Indianapolis, Ind.
11236	C.P.S. of Berne, Inc., Berne, Ind. 46711	73445	Amperex Electronics Co., Hicksville, N. Y.	90750	Westinghouse Electric Corp., Boston, Mass.
11599	Chandler Evans Corp., W. Hartford, Conn.	73559	Carling Electric Co., W. Hartford, Conn.	90952	Hardware Products Co., Reading, Penn. 19602
12498	Teledyn Inc., Crystallines Div., Cambridge, Mass. 02140	73690	Elco Resistor Co., New York, N. Y.	91032	Continental Wire Corp., York, Penn. 17405
12672	RCA Commercial Receiving Tube and Semi- conductor Div., Woodridge, N.J.	73899	J. F. D. Electronics Corp., Brooklyn, N. Y.	91146	ITT Cannon Electric Inc., Salem, Mass.
12697	Clarostat Mfg. Co. Inc., Dover, N. H. 03820	74193	Heinemann Electric Co., Trenton, N. J.	91293	Johnson Mfg. Co., Bonton, N. J. 07005
12954	Dickson Electronics Corp., Scottsdale, Ariz.	74861	Industrial Condenser Corp., Chicago, Ill.	91598	Chandler Co., Wethersfield, Conn. 06109
13327	Solitrone Devices, Tappan, N. Y. 10983	74970	E. F. Johnson Co., Waseca, Minn. 56093	91637	Dale Electronics Inc., Columbus, Nebr.
14433	ITT Semiconductors, W. Palm Beach, Florida	75042	IRC Inc., Philadelphia, Penn. 19108	91662	Elco Corp., Willow Grove, Penn.
14655	Cornell Dubilier Electric Co., Newark N. J.	75382	Kulka Electric Corp., Mt. Vernon, N. Y.	91719	General Instruments, Inc., Dallas, Texas
14674	Coming Glass Works, Corning, N. Y.	75491	Lafayette Industrial Electronics, Jamaica, N.Y.	91929	Honeywell Inc., Freeport, Ill.
14936	General Instrument Corp., Hicksville, N. Y.	75608	Linden and Co., Providence, R. I.	92519	Electra Insulation Corp., Woodside, Long Island, N. Y.
15238	ITT, Semiconductor Div. of Int. T. and T., Lawrence, Mass.	75915	Littelfuse, Inc., Des Plaines, Ill. 60016	92678	Edgerton, Germeshausen and Grier, Boston, Mass.
15605	Cutler-Hammer Inc., Milwaukee, Wisc. 53233	76005	Lord Mfg. Co., Erie, Penn. 16512	93332	Sylvania Electric Products, Inc., Woburn, Mass.
16037	Spruce Pine Mica Co., Spruce Pine, N. C.	76149	Malloy Electric Corp., Detroit, Mich. 48204	93916	Cramer Products Co., New York, N. Y. 10013
19644	LRC Electronics, Horseheads, New York	76487	James Millen Mfg. Co., Malden, Mass. 02148	94144	Raytheon Co. Components Div., Quincy, Mass.
19701	Electra Mfg. Co., Independence, Kansas 67301	76545	Mueller Electric Co., Cleveland, Ohio 44114	94154	Tung Sol Electric Inc., Newark, N. J.
21335	Fafnir Bearing Co., New Briton, Conn.	76684	National Tube Co., Pittsburg, Penn.	95076	Garde Mfg. Co., Cumberland, R. I.
24446	G. E. Schenectady, N. Y. 12305	76854	Oak Mfg. Co., Crystal Lake, Ill.	95146	Alco Electronics Mfg. Co., Lawrence, Mass.
24454	G. E., Electronic Comp., Syracuse, N. Y.	77147	Patton MacGuyre Co., Providence, R. I.	95238	Continental Connector Corp., Woodside, N. Y.
24455	G. E. (Lamp Div), Nela Park, Cleveland, Ohio	77166	Pass-Seymour, Syracuse, N. Y.	95275	Vitramon, Inc., Bridgeport, Conn.
24655	General Radio Co., W. Concord, Mass 01781	77263	Pierce Roberts Rubber Co., Trenton, N. J.	95354	Methode Mfg. Co., Chicago, Ill.
26806	American Zettler Inc., Costa Mesa, Calif.	77339	Positive Lockwasher Co., Newark, N. J.	95412	General Electric Co., Schenectady, N. Y.
28520	Hayman Mfg. Co., Kenilworth, N. J.	77542	Ray-O-Vac Co., Madison, Wisc.	95794	Ansonda American Brass Co., Torrington, Conn.
28959	Hoffman Electronics Corp., El Monte, Calif.	77630	TRW, Electronic Component Div., Camden, N. J. 08103	96095	Hi-Q Div. of Aerovox Corp., Orlean, N. Y.
30874	International Business Machines, Armonk, N.Y.	77638	General Instruments Corp., Brooklyn, N. Y.	96214	Texas Instruments Inc., Dallas, Texas 75209
32001	Jensen Mfg. Co., Chicago, Ill. 60638	78189	Shakeproof Div. of Ill. Tool Works, Elgin, Ill. 60120	96256	Thordarson-Meissner Div. of McGuire, Mt. Carmel, Ill.
35929	Constanta Co. of Canada Limited, Montreal 19, Quebec	78277	Sigma Instruments Inc., S. Braintree, Mass.	96341	Microwave Associates Inc., Burlington, Mass.
37942	P. R. Mallory and Co. Inc., Indianapolis, Ind.	78488	Stackpole Carbon Co., St. Marys, Penn.	96791	Amphenol Corp., Jonesville, Wisc. 53545
38443	Marlin-Rockwell Corp., Jamestown, N. Y.	78553	Tinnerman Products, Inc., Cleveland, Ohio	96906	Military Standards
40931	Honeywell Inc., Minneapolis, Minn. 55408	79089	RCA, Commercial Receiving Tube and Semi- conductor Div., Harrison, N. J.	97966	CBS Electronics Div. of Columbia Broadcast- ing Systems, Danvers, Mass.
42190	Muter Co., Chicago, Ill. 60638	79725	Wiremold Co., Hartford, Conn. 06110	98291	Sealectro Corp., Mamaroneck, N. Y. 10544
42498	National Co. Inc., Melrose, Mass. 02176	79963	Zierick Mfg. Co., New Rochelle, N. Y.	98821	North Hills Electronics Inc., Glen Cove, N. Y.
43991	Norma-Hoffman Bearings Corp., Stanford, Conn. 06904	80030	Prestole Fastener Div. Bishop and Babcock Corp., Toledo, Ohio	99180	Transitron Electronics Corp., Melrose, Mass.
49671	RCA, New York, N. Y.	80048	Vickers Inc. Electric Prod. Div., St. Louis, Mo.	99378	Atlee Corp., Winchester, Mass. 01890
49956	Raytheon Mfg. Co., Waltham, Mass. 02154	80131	Electronic Industries Assoc., Washington, D.C.	99800	Delevan Electronics Corp., E. Aurora, N. Y.
		80183	Sprague Products Co., N. Adams, Mass.		
		80211	Motorola Inc., Franklin Park, Ill. 60131		
		80258	Standard Oil Co., Lafayette, Ind.		
		80294	Bourms Inc., Riverside, Calif. 92506		

MECHANICAL PARTS LIST

Ref. No.	Description	Part No.	Fed. Mfg. Code	Mfg. Part No.	Fed. Stock No.
MISCELLANEOUS					
	Etched Circuit Assembly Comp.	1820-2711	24655	1820-2711	
	Etched Circuit Assembly Comp.	1820-2721	24655	1820-2721	
	Etched Circuit Assembly Comp.	1820-2731	24655	1820-2731	
	Etched Circuit Assembly Comp.	1820-2741	24655	1820-2741	
	Etched Circuit Assembly Comp.	1820-2751	24655	1820-2751	
	Etched Circuit Assembly Comp.	1820-2761	24655	1820-2761	
	Etched Circuit Assembly Comp.	1820-2771	24655	1820-2771	
	Etched Circuit Assembly Comp.	1820-2781	24655	1820-2781	
	Power Cord	4200-9622	24655	4200-9622	6150-968-0081
	Indicator Frame Assembly	5315-2050	24655	5315-2050	
	Rail	5315-8050	24655	5315-8050	
	Window	8170-7050	24655	8170-7050	
	Handles	5360-2012	24655	5360-2012	
	Indicator Assembly	5437-1853	24655	5437-1853	
	Indicator Assembly	5437-1866	24655	5437-1866	
	Digital Indicator	5437-1803	24655	5437-1803	
	Digital Indicator	5437-1816	24655	5437-1816	
	Knob	5500-5221	24655	5500-5221	
	Knob	5520-5221	24655	5520-5221	

PLUG IN

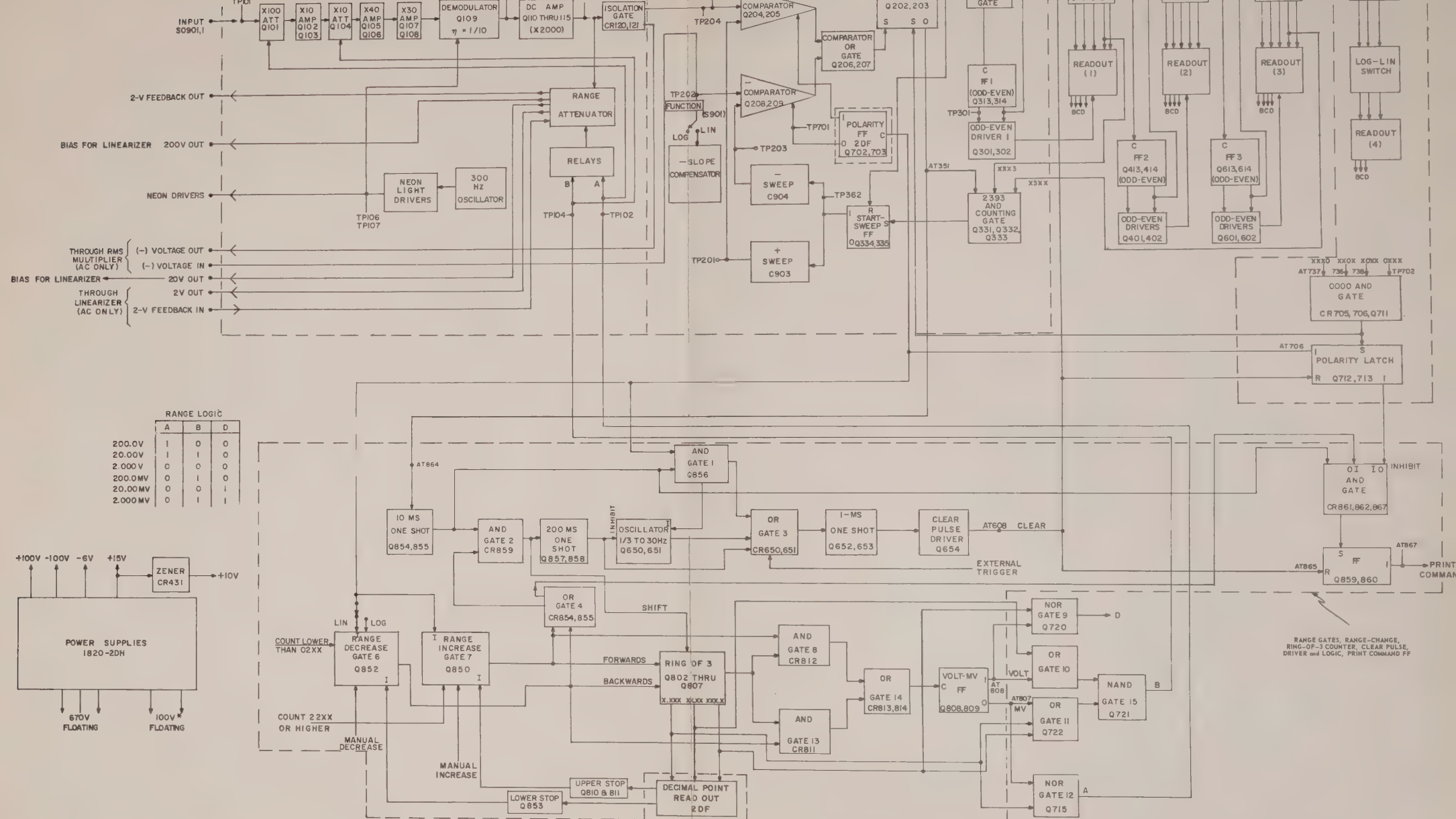


Figure 6-1. Block Diagram.

ELECTRICAL PARTS LIST

Ref. No.	Description	Part No.	Fed. Mfg. Code	Mfg. Part No.	Fed. Stock No.
CAPACITORS					
C901	Ceramic, 0.01 μ F +80-20% 500 V	4406-3109	72982	811, 0.01 μ F +80-20%	5910-977-7579
C902	Ceramic, 0.0068 pF +80-20% 500 V	4406-2689	72982	811, 0.0068 pF +80-20%	
C903	Ceramic, 0.15 μ F	0505-4022	24655	0505-4022	
C904	Ceramic, 0.15 μ F	0505-4022	24655	0505-4022	
C905	Plastic, 1.0 μ F $\pm$ 10% 400 V	4860-9850	84411	663 F, 1.0 μ F $\pm$ 10%	
RESISTORS					
R901	(Includes S910) Potentiometer, composition, 1 M Ω $\pm$ 20%				
R911	Composition, 100 k Ω $\pm$ 5% 1/2 W	6100-4105	01121	RC20GF104J	5905-195-6761
R950	Composition, 47 k Ω $\pm$ 5% 1/4 W	6099-3475	75042	BTS, 47 k Ω $\pm$ 5%	
R953	Composition, 2 k Ω $\pm$ 5% 1/4 W	6099-2205	75042	BTS, 2 k Ω $\pm$ 5%	5905-279-4629
R954	Composition, 47 k Ω $\pm$ 5% 1/4 W	6099-3475	75042	BTS, 47 k Ω $\pm$ 5%	
R955	Composition, 2 k Ω $\pm$ 5% 1/4 W	6099-2205	75042	BTS, 2 k Ω $\pm$ 5%	5905-279-4629
R961	Composition, 47 k Ω $\pm$ 5% 1/4 W	6099-3475	75042	BTS, 47 k Ω $\pm$ 5%	
R962	Composition, 2 k Ω $\pm$ 5% 1/4 W	6099-2205	75042	BTS, 2 k Ω $\pm$ 5%	
R963	Composition, 47 k Ω $\pm$ 5% 1/4 W	6099-3475	75042	BTS, 47 k Ω $\pm$ 5%	
R970					
MISCELLANEOUS					
X301	CRYSTAL	1520-0490	24655	1520-0490	
F901	FUSE, 0.5 A	5330-1000	71400	MDL, 0.5 A	5920-199-9498
F902	FUSE, 0.25 A	5330-0700	71400	MDL, 0.25 A	5920-933-5435
L301	INDUCTOR, 10 mH $\pm$ 10%	4300-6200	99800	3500-42	
J901	JACK	0938-3002	24655	0938-3002	
J902	JACK	0938-3002	24655	0938-3002	
PL901	Lamps for Indicators	5600-0309	71744	#330	
SO901	PLUG	4240-0600	24655	4240-0600	
SO902	SOCKET	4230-2735	71785	36-4200-24S	
SO903	SOCKET	4230-2740	71785	26-4200-32S	
SO904	SOCKET	4230-5000	02660	220-698-01	
S901	SWITCH	4230-3400	71785	S-304-AB	
S902	SWITCH	7890-3680	76854	Type F	5930-914-6723
S903	SWITCH	7910-1500	04009	83054-SA	
S904	SWITCH	7910-1660			
S905	SWITCH	7910-1300	04009	83053-SA	5930-909-3510
S910	Part of R910	7910-0831	42190	4603	
T901	TRANSFORMER	0485-4023	24655	0485-4023	
Q901	TRANSISTOR, Type 2N1540	8210-1540	80211	2N1540	

SOCKET CONNECTIONS

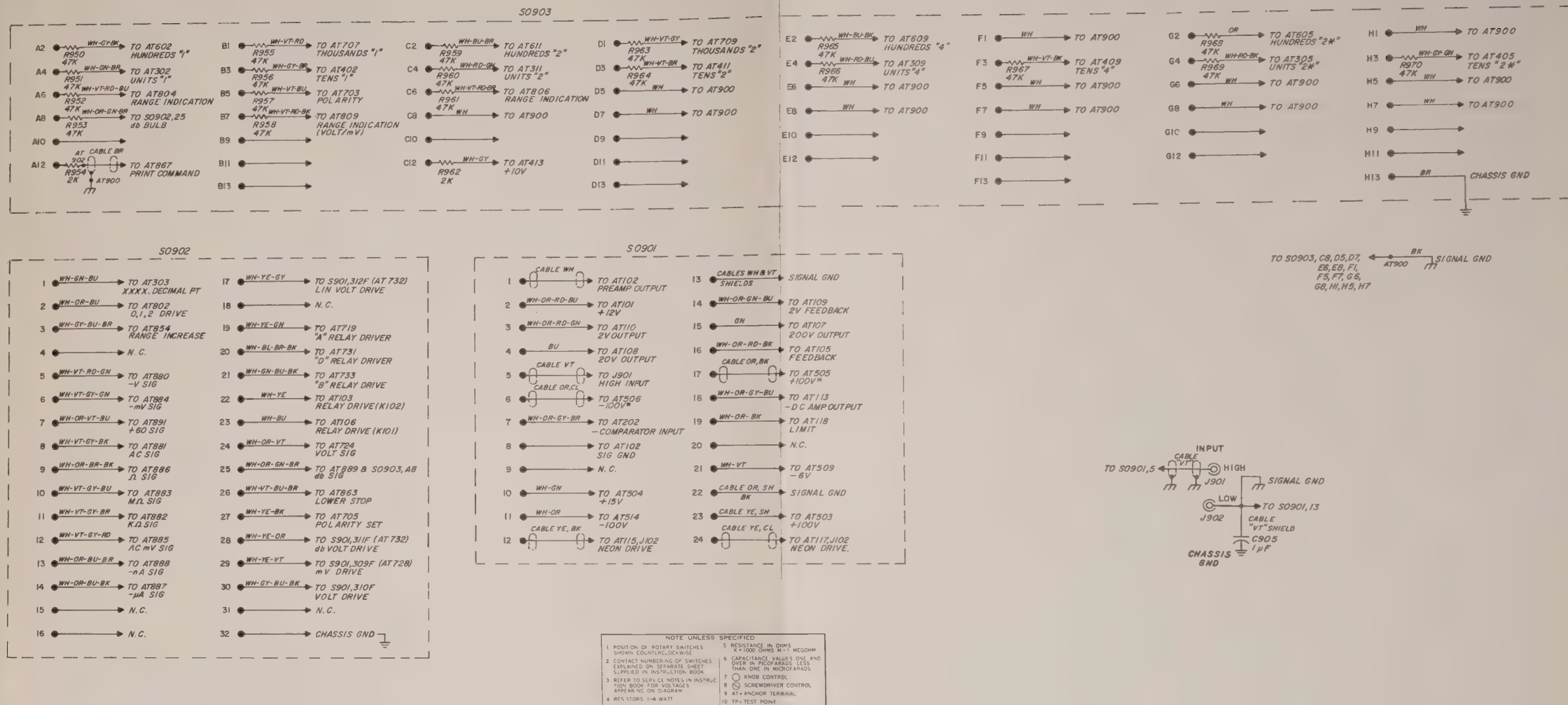


Figure 6-2. Socket diagrams for SO901, SO902, and SO903.

ELECTRICAL PARTS LIST

ELECTRICAL PARTS LIST (cont)

ELECTRICAL PARTS LIST (cont)

Ref. No.	Description	Part No.	Fed. Mfg. Code	Mfg. Part No.	Fed. Stock No.
CAPACITORS					
C101A	Electrolytic, 300-300 μ F 15 V	4450-2400	37942	2021149S4C10X1	5910-822-2691
C101B	Plastic, 0.022 μ F $\pm 10\%$ 100 V	4860-7860	84411	663UW, 0.022 μ F $\pm 10\%$	
C102	Ceramic, 0.47 μ F $\pm 80-20\%$ 12 V	4428-4479	56289	41C172	
C103	Ceramic, 0.47 μ F $\pm 80-20\%$ 12 V	4428-4479	56289	41C172	
C104	Ceramic, 1 μ F $\pm 20\%$ 25 V	4400-2070	80183	5C13, 1 μ F $\pm 20\%$	
C105	Electrolytic, 40 μ F 6 V	4450-3600	37942	20-4070754	5910-952-0467
C106	Electrolytic, 5 μ F 50 V	4450-3900	37942	2040595S9C10X3	5910-448-5527
C107	Ceramic, 1 μ F $\pm 20\%$ 25 V	4400-2070	80183	5C13, 1 μ F $\pm 20\%$	
C108	Ceramic, $\pm 80-20\%$ 12 V	4428-4479	56289	41C172	
C109	Ceramic, $\pm 80-20\%$ 12 V	4428-4479	56289	41C172	
C110	Plastic, 0.01 μ F $\pm 10\%$ 100 V	4860-7750	84411	663UW, 0.01 μ F $\pm 10\%$	
C111	Electrolytic, 5 μ F 50 V	4450-3900	37942	2040595S9C10X3	5910-448-5527
C112	Electrolytic, 15 μ F 15 V	4450-3700	37942	TT, 15 μ F 15 V	
C113	Plastic, 0.015 μ F $\pm 10\%$ 100 V	4860-7655	84411	663UW, 0.015 μ F $\pm 10\%$	
C114	Electrolytic, 10 μ F 25 V	4450-3800	56289	30D106G025BB4M1	5910-952-8658
C115	Electrolytic, 10 μ F 25 V	4450-3800	56289	30D106G025BB4M1	5910-952-8658
C116	Plastic, 0.22 μ F $\pm 10\%$ 100 V	4860-7981	84411	620S22491	5910-957-6509
C117	Plastic, 1 μ F $\pm 10\%$ 100 V	4860-8274	84411	663UW, 1 μ F $\pm 10\%$	
C118	Electrolytic, 2.2 μ F $\pm 20\%$ 20 V	4450-4500	56289	150D225X0020A2	5910-976-4604
C119	Plastic, 0.33 μ F $\pm 10\%$ 400 V	4860-9700	84411	663F, 0.33 μ F $\pm 10\%$	
C120	Ceramic, 1 μ F $\pm 20\%$ 25 V	4400-2070	80183	5C13, 1 μ F $\pm 20\%$	
C121	Electrolytic, 4 μ F 475 V	4450-2000	80183	D32845	5910-893-0879
C122	Electrolytic, 4 μ F 475 V	4450-2000	80183	D32845	5910-893-0879
C123	Plastic, 0.1 μ F $\pm 10\%$ 400 V	4860-7886	84411	663UW, 0.1 μ F $\pm 10\%$	
C124	Plastic, 0.1 μ F $\pm 10\%$ 400 V	4860-7886	84411	663UW, 0.1 μ F $\pm 10\%$	
C125	Plastic, 0.47 μ F $\pm 10\%$ 100 V	4860-8248	84411	663UW, 0.47 μ F $\pm 10\%$	
C126	Plastic, 0.22 μ F $\pm 10\%$ 100 V	4860-7981	84411	620S22491	5910-957-6509
C127	Plastic, 0.022 μ F $\pm 10\%$ 100 V	4860-7860	84411	663UW, 0.022 μ F $\pm 10\%$	
C128	Plastic, 0.1 μ F $\pm 1\%$ 100 V	4860-8249	84411	GR-8, 0.1 μ F $\pm 1\%$	
C129	Plastic, 0.1 μ F $\pm 1\%$ 100 V	4860-8249	84411	GR-8, 0.1 μ F $\pm 1\%$	
C130	Plastic, 0.022 μ F $\pm 10\%$ 100 V	4860-7860	84411	663UW, 0.022 μ F $\pm 10\%$	

DIODES

CR101	Type 1N4442	6082-1009	24446	1N4442	5961-929-9967
CR102	Type 1N4442	6082-1009	24446	1N4442	5961-929-9967
CR103	Type 1N965B 15 V $\pm 5\%$ 0.4 W	6083-1015	07910	1N965B	5960-877-6192
CR104	Type 1N965B 15 V $\pm 5\%$ 0.4 W	6083-1015	07910	1N965B	5960-877-6192
CR105	Type 1N4009	6082-1012	24446	1N4009	
CR106	Type 1N4009	6082-1012	24446	1N4009	
CR107	Type 1N3254	6081-1002	09213	1N3254	5961-082-3988
CR108	Type 1N989B 150 V $\pm 5\%$ 0.4 W	6083-1035	80211	1N989B	
CR109	Type 1N989B 150 V $\pm 5\%$ 0.4 W	6083-1035	80211	1N989B	
CR110	Type 1N957B 6.8 V $\pm 5\%$ 0.4 W	6083-1009	07910	1N957B	
CR111	Type 1N957B 6.8 V $\pm 5\%$ 0.4 W	6083-1009	07910	1N957B	
CR112	Type 1N957B 6.8 V $\pm 5\%$ 0.4 W	6083-1009	07910	1N957B	
CR120	Type 1N3254	6081-1002	09213	1N3254	5961-082-3988
CR121	Type 1N3254	6081-1002	09213	1N3254	5961-082-3988
CR122	Type 1N978A 51 V $\pm 5\%$ 0.4 W	6083-1052	80131	1N978B	5960-858-4212
CR123					
thru	Type 1N4009	6082-1012	24446	1N4009	
CR127					

RESISTORS

R100	Thermistor, 100 k Ω $\pm 10\%$				
R101	Composition, 470 Ω $\pm 5\%$ 1/2 W	6100-1475	01121	RC20GF471J	5905-192-3973
R102	Composition, 470 Ω $\pm 5\%$ 1/2 W	6100-1475	01121	RC20GF471J	5905-192-3973
R103	Composition, 4.7 k Ω $\pm 5\%$ 1/2 W	6100-2475	01121	RC20GF472J	5905-279-3504
R104	Composition, 4.7 k Ω $\pm 5\%$ 1/2 W	6100-2475	01121	RC20GF472J	5905-279-3504
R105	Composition, 10 k Ω $\pm 5\%$ 1/2 W	6100-3105	01121	RC20GF103J	5905-185-8510
R106	Composition, 10 k Ω $\pm 5\%$ 1/2 W	6100-3105	01121	RC20GF103J	5905-185-8510
R107	Composition, 47 k Ω $\pm 5\%$ 1/2 W	6100-3475	01121	RC20GF473J	5905-254-9201
R108	Composition, 22 Ω $\pm 5\%$ 1/2 W	6100-0225	01121	RC20GF220J	5905-279-3519
R109	Composition, 22 k Ω $\pm 5\%$ 1/2 W	6100-3225	01121	RC20GF223J	5905-171-2004
R110	Composition, 15 k Ω $\pm 5\%$ 1/2 W	6100-3155	01121	RC20GF153J	5905-279-2616
R111	Composition, 22 k Ω $\pm 5\%$ 1/2 W	6100-3225	01121	RC20GF223J	5905-171-2004
R112	Composition, 62 k Ω $\pm 5\%$ 1/2 W	6100-3625	01121	RC20GF623J	5905-249-3656
R113	Composition, 4.7 k Ω $\pm 5\%$ 1/2 W	6100-2475	01121	RC20GF472J	5905-279-3504
R114	Composition, 360 Ω $\pm 5\%$ 1/2 W	6100-1365	01121	RC20GF361J	5905-279-1889
R115	Composition, 6.2 k Ω $\pm 5\%$ 1/2 W	6100-2625	01121	RC20GF622J	5905-279-2673
R116	Composition, 4.7 k Ω $\pm 5\%$ 1/2 W	6100-2475	01121	RC20GF472J	5905-279-3504

Ref. No.	Description	Part No.	Fed. Mfg. Code	Mfg. Part No.	Fed. Stock No.
RESISTORS (Cont)					
R117	Composition, 220 Ω $\pm 5\%$ 1/2 W	6100-1225	01121	RC20GF221J	5905-279-3513
R118	Composition, 47 k Ω $\pm 5\%$ 1/2 W	6100-3475	01121	RC20GF473J	5905-254-9201
R119	Composition, 10 k Ω $\pm 5\%$ 1/2 W	6100-3105	01121	RC20GF103J	5905-185-8510
R120	Composition, 15 k Ω $\pm 5\%$ 1/2 W	6100-3155	01121	RC20GF153J	5905-279-2616
R121	Composition, 22 k Ω $\pm 5\%$ 1/2 W	6100-3225	01121	RC20GF223J	5905-171-2004
R122	Composition, 12 k Ω $\pm 5\%$ 1/2 W	6100-3125	01121	RC20GF123J	5905-279-3502
R123	Composition, 62 k Ω $\pm 5\%$ 1/2 W	6100-3625	01121	RC20GF623J	5905-249-3656
R124	Composition, 15 k Ω $\pm 5\%$ 1/2 W	6100-3155	01121	RC20GF153J	5905-279-2616
R125	Composition, 22 k Ω $\pm 5\%$ 1/2 W	6100-3225	01121	RC20GF223J	5905-171-2004
R126	Composition, 360 Ω $\pm 5\%$ 1/2 W	6100-1365	01121	RC20GF361J	5905-279-1889
R127	Composition, 6.2 k Ω $\pm 5\%$ 1/2 W	6100-2625	01121	RC20GF622J	5905-279-2673
R128	Composition, 4.7 k Ω $\pm 5\%$ 1/2 W	6100-2475	01121	RC20GF472J	5905-279-3504
R129	Composition, 24 k Ω $\pm 5\%$ 1/2 W	6100-3245	01121	RC20GF243J	5905-279-1878
R130	Composition, 22 k Ω $\pm 5\%$ 1/2 W	6100-3225	01121	RC20GF223J	5905-171-2004
R131	Composition, 2.2 k Ω $\pm 5\%$ 1/2 W	6100-2225	01121	RC20GF222J	5905-279-1876
R132	Composition, 10 k Ω $\pm 5\%$ 1/2 W	6100-3105	01121	RC20GF103J	5905-185-8510
R133	Composition, 10 k Ω $\pm 5\%$ 1/2 W	6100-3105	01121	RC20GF103J	5905-185-8510
R134	Composition, 47 k Ω $\pm 5\%$ 1/2 W	6100-3475	01121	RC20GF473J	5905-254-9201
R135	Composition, 2.2 k Ω $\pm 5\%$ 1/2 W	6100-2225	01121	RC20GF222J	5905-279-1876
R136	Composition, 24 k Ω $\pm 5\%$ 1/2 W	6100-3245	01121	RC20GF243J	5905-279-1878
R137	Composition, 200 Ω $\pm 5\%$ 1/2 W	6100-1205	01121	RC20GF201J	5905-279-2674
R138	Composition, 3 k Ω $\pm 5\%$ 1/2 W	6100-2305	01121	RC20GF302J	5905-279-1751
R139	Composition, 20 k Ω $\pm 5\%$ 1/2 W	6100-3205	01121	RC20GF203J	5905-192-0649
R140	Composition, 39 k Ω $\pm 5\%$ 1/2 W	6100-3395	01121	RC20GF393J	5905-279-3497
R141	Composition, 430 Ω $\pm 5\%$ 1/2 W	6100-1435	01121	RC20GF431J	5905-279-3512
R142	Composition, 24 k Ω $\pm 5\%$ 1/2 W	6100-3245	01121	RC20GF243J	5905-279-1878
R143	Composition, 150 Ω $\pm 5\%$ 1/2 W	6100-1155	01121	RC20GF151J	5905-299-1541
R144	Composition, 10 k Ω $\pm 5\%$ 1/2 W	6100-3105	01121	RC20GF103J	5905-185-8510
R145	Composition, 100 k Ω $\pm 5\%$ 1/2 W	6100-4105	01121	RC20GF104J	5905-195-6761
R146	Composition, 200 k Ω $\pm 5\%$ 1/2 W	6100-4205	01121	RC20GF204J	5905-171-2003
R147	Composition, 100 k Ω $\pm 5\%$ 1/2 W	6100-4105	01121	RC20GF104J	5905-195-6761
R148	Composition, 33 k Ω $\pm 5\%$ 1/2 W	6100-3335	01121	RC20GF333J	5905-171-1998
R149	Composition, 150 Ω $\pm 5\%$ 1/2 W	6100-1155	01121	RC20GF151J	5905-299-1541
R150	Composition, 620 k Ω $\pm 5\%$ 1/2 W	6100-4625	01121	RC20GF624J	5905-221-5841
R151	Composition, 4.3 k Ω $\pm 5\%$ 1/2 W	6100-2435	01121	RC20GF432J	5905-257-0935
R152	Composition, 15 k Ω $\pm 5\%$ 1/2 W	6100-3155	01121	RC20GF153J	5905-279-2616
R153	Composition, 200 k Ω $\pm 5\%$ 1/2 W	6100-4205	01121	RC20GF204J	5905-171-2003
R154	Composition, 240 Ω $\pm 5\%$ 1/2 W	6100-1245	01121	RC20GF241J	5905-279-2593
R155	Composition, 2 M Ω $\pm 5\%$ 1/2 W	6100-5205	01121	RC20GF205J	5905-279-1875
R156	Composition, 470 Ω $\pm 5\%$ 1/2 W	6100-1475	01121	RC20GF471J	5905-192-3973
R157	Composition, 1 M Ω $\pm 5\%$ 1/2 W	6100-5105	01121	RC20GF105J	5905-192-0390
R158	Composition, 1 M Ω $\pm 5\%$ 1/2 W	6100-5105	01121	RC20GF105J	5905-192-0390
R159	Wire wound, 180 k Ω $\pm 0.01\%$ 77 W	6983-6002	24655	6983-6002	
R160	Wire wound, 5.941 Ω $\pm 0.01\%$ 77 W	6983-4005	24655	6983-4005	
R161	Wire wound, 18 k Ω $\pm 0.01\%$ 77 W	6982-5006	24655	6982-5006	
R162	Composition, 55.6 Ω $\pm 1\%$ 1/2 W	6450-9556	75042	CEC-TO, 55.6 Ω $\pm 1\%$	
R163	Wire wound, 1.8 k Ω $\pm 0.01\%$ 77 W	6983-4003	24655	6983-4003	
R164	Wire wound, 200 Ω $\pm 0.01\%$ 77 W	6983-3003	24655	6983-3003	
R165	Composition, 7.5 k Ω $\pm 5\%$ 1/2 W	6100-2755	01121	RC20GF752J	5905-249-4195
R166	Composition, 10 M Ω $\pm 5\%$ 1/2 W	6100-6105	01121	RC20GF106J	5905-279-1865
R167	Wire wound, 200 k Ω $\pm 0.01\%$ 77 W	6983-6003	24655	6983-6003	
R168	Wire wound, 16 k Ω $\pm 0.01\%$ 77 W	6983-5005	24655	6983-5005	
R169	Composition, 10 M Ω $\pm 5\%$ 1/2 W	6100-6105	01121	RC20GF106J	5905-279-1865
R170	Wire wound, 200 k Ω $\pm 0.01\%$ 77 W	6983-6003	24655	6983-6003	
R171	Composition, 100 k Ω $\pm 5\%$ 1/2 W	6100-4105	01121	RC20GF104J	5905-195-6761
R172	Composition, 330 Ω $\pm 5\%$ 1/2 W	6100-1335	01121	RC20GF331J	5905-192-3971
R173	Composition, 33 k Ω $\pm 5\%$ 1/2 W	6100-3335	01121	RC20GF333J	5905-171-1998
R174	Composition, 7.5 k Ω $\pm 5\%$ 1/2 W	6100-2755	01121	RC20GF752J	5905-249-4195
R175	Composition, 1 M Ω $\pm 5\%$ 1/2 W	6100-5105	01121	RC20GF105J	5905-192-0390
R176	Composition, 15 k Ω $\pm 5\%$ 1/2 W	6100-3155	01121	RC20GF153J	5905-279-2616
R177	Composition, 1 k Ω $\pm 5\%$ 1/2 W	6100-2105	01121	RC20GF102J	5905-195-6806
R178	Film, 22 k Ω $\pm 1\%$ 1/2 W	6450-2220	75042	CEC, 22 k Ω $\pm 1\%$	
R179	Film, 22 k Ω $\pm 1\%$ 1/2 W	6450-2220	75042	CEC, 22 k Ω $\pm 1\%$	
R180	Composition, 1 k Ω $\pm 5\%$ 1/2 W	6100-2105	01121	RC20GF102J	5905-195-6806
R181	Composition, 15 k Ω $\pm 5\%$ 1/2 W	6100-3155	01121	RC20GF153J	5905-279-2616
R182	Composition, 47 k Ω $\pm 5\%$ 1/2 W	6100-3475	01121	RC20GF473J	5905-254-9201
R183	Composition, 2 k Ω $\pm 5\%$ 1/2 W	6100-2205	01121	RC20GF202J	5905-190-8887
R184	Composition, 2 k Ω $\pm 5\%$ 1/2 W	6100-2205	01121	RC20GF202J	5905-190-8887
R185	Composition, 120 k Ω $\pm 5\%$ 2 W	6120-4125	01121	RC42GF124J	5905-254-7110
R186	Composition, 120 k Ω $\pm 5\%$ 2 W	6120-4125	01121	RC42GF124J	5905-254-7110
R187	Composition, 470 Ω $\pm 5\%$ 1/2 W	6100-1475	01121	RC20GF471J	5905-192-3973
R188	Composition, 51 k Ω $\pm 5\%$ 1/2 W	6100-3515	01121	RC20GF513J	5905-279-3494

ELECTRICAL PARTS LIST

Ref. No.	Description	Part No.	Fed. Mfg. Code	Mfg. Part No.	Fed. Stock No.
CAPACITORS					
C201	Plastic, 1 μ F $\pm$ 10% 100 V	4860-8274	84411	663UW, 1 μ F $\pm$ 10%	
C202	Plastic, 1 μ F $\pm$ 10% 100 V	4860-8274	84411	663UW, 1 μ F $\pm$ 10%	
C209	Ceramic, 470 pF $\pm$ 10% 500 V	4404-1478	72982	831, 470 pF $\pm$ 10%	
C210	Ceramic, 470 pF $\pm$ 10% 500 V	4404-1478	72982	831, 470 pF $\pm$ 10%	
C211	Ceramic, 470 pF $\pm$ 10% 500 V	4404-1478	72982	831, 470 pF $\pm$ 10%	
C212	Ceramic, 0.05 μ F +80-20% 50 V	4403-3500	01121	40-503W, 0.05 μ F +80-20%	
C213	Ceramic, 1 μ F $\pm$ 20% 25 V	4400-2070	80183	5C13, 1 μ F $\pm$ 20%	
DIODES					
CR201 thru CR217	Type 1N4442	6082-1009	24446	1N4442	5961-929-9967
CR218	Type 1N3604	6082-1001	24446	1N3604	5960-995-2199
CR219	Type 1N4442	6082-1009	24446	1N4442	5961-929-9967
CR220	Type 1N4442	6082-1009	24446	1N4442	5961-929-9967
CR221	Type 1N968A 20 V $\pm$ 10% 0.4 W	6083-1017	07910	1N968A	5961-933-7697
CR222	Type 1N4442	6082-1009	24446	1N4442	5961-929-9967
CR223	Type 1N4442	6082-1009	24446	1N4442	5961-929-9967
CR224	Type 1N4442	6082-1009	24446	1N4442	5961-929-9967
CR225	Type 1N968A 20 V $\pm$ 10% 0.4 W	6083-1017	07910	1N968A	5961-933-7697
CR226 thru CR229	Type 1N4442	6082-1009	24446	1N4442	5961-929-9967
CR230	Type 1N3689B 27 V $\pm$ 5% 0.75 W	6083-1032	79089	LMZ-27.0A	
CR231	Type 1N3604	6082-1001	24446	1N3604	5960-995-2199
CR232	Type 1N3604	6082-1001	24446	1N3604	5960-995-2199
RESISTORS					
R201	Film, 1.5 k Ω $\pm$ 1% 1/8 W	6250-1150	75042	CEA, 1.5 k Ω $\pm$ 1%	5905-581-6913
R202	Film, 590 k Ω $\pm$ 1% 1/2 W	6193-3590	75042	MEC, 590 k Ω $\pm$ 1%	
R203	Film, 2.37 k Ω $\pm$ 1% 1/8 W	6250-1237	75042	CEA, 2.37 k Ω $\pm$ 1%	
R204	Film, 590 k Ω $\pm$ 1% 1/2 W	6193-3590	75042	MEC, 590 k Ω $\pm$ 1%	
R205	Film, 2.7 k Ω $\pm$ 1% 1/8 W	6250-1270	75042	CEA, 2.7 k Ω $\pm$ 1%	
R206	Film, 590 k Ω $\pm$ 1% 1/2 W	6193-3590	75042	MEC, 590 k Ω $\pm$ 1%	
R207	Film, 2.05 k Ω $\pm$ 1% 1/8 W	6250-1205	75042	CEA, 2.05 k Ω $\pm$ 1%	
R208	Film, 590 k Ω $\pm$ 1% 1/2 W	6193-3590	75042	MEC, 590 k Ω $\pm$ 1%	
R209	Film, 2.61 k Ω $\pm$ 1% 1/8 W	6250-1261	75042	CEA, 2.61 k Ω $\pm$ 1%	
R210	Film, 590 k Ω $\pm$ 1% 1/2 W	6193-3590	75042	MEC, 590 k Ω $\pm$ 1%	
R211	Composition, 10 M Ω $\pm$ 5% 1/2 W	6100-6105	01121	RC20GF106J	5905-279-1865
R212	Film, 2.43 k Ω $\pm$ 1% 1/8 W	6250-1243	75042	CEA, 2.43 k Ω $\pm$ 1%	5905-577-1685
R213	Film, 590 k Ω $\pm$ 1% 1/2 W	6193-3590	75042	MEC, 590 k Ω $\pm$ 1%	
R214	Film, 84.5 k Ω $\pm$ 1% 1/8 W	6250-2845	75042	CEA, 84.5 k Ω $\pm$ 1%	
R215	Potentiometer, wire wound, 10 k Ω $\pm$ 10%	6051-3109	02260	2600-PC, 10 k Ω $\pm$ 10%	
R216	Composition, 207 k Ω $\pm$ 0.05% 1 W	6983-6004	24655	6983-6004	
R217	Potentiometer, wire wound 5 k Ω $\pm$ 10%	6051-2509	02660	2600-PC, 5 k Ω $\pm$ 10%	
R218	Composition, 11.35 k Ω $\pm$ 0.025% 1 W	6983-5002	24655	6983-5002	
R219	Potentiometer, wire wound 500 Ω $\pm$ 10%	6051-1509	02660	2600-PC, 500 Ω $\pm$ 10%	
R220	Film, 5 M Ω $\pm$ 1% 1/2 W	6450-4500	75042	CEC, 5 M Ω $\pm$ 1%	
R221	Film, 10 M Ω $\pm$ 1% 1/2 W	6450-5100	75042	CEC, 10 M Ω $\pm$ 1%	
R222	Potentiometer, composition 500 k Ω $\pm$ 20%	6001-4509	80294	3068P, 500 k Ω $\pm$ 20%	
R223	Composition, 10 k Ω $\pm$ 10%	6051-3109	02660	2600-PC, 10 k Ω $\pm$ 10%	
R224	Film, 84.5 k Ω $\pm$ 1% 1/8 W	6250-2845	75042	CEA, 84.5 k Ω $\pm$ 1%	
R225	Film, 590 k Ω $\pm$ 1% 1/2 W	6193-3590	75042	MEC, 590 k Ω $\pm$ 1%	
R226	Film, 2.43 k Ω $\pm$ 1% 1/8 W	6250-1243	75042	CEA, 2.43 k Ω $\pm$ 1%	5905-577-1685
R227	Film, 590 k Ω $\pm$ 1% 1/2 W	6193-3590	75042	MEC, 590 k Ω $\pm$ 1%	
R228	Film, 2.61 k Ω $\pm$ 1% 1/8 W	6250-1261	75042	CEA, 2.61 k Ω $\pm$ 1%	
R229	Film, 590 k Ω $\pm$ 1% 1/2 W	6193-3590	75042	MEC, 590 k Ω $\pm$ 1%	
R230	Film, 2.05 k Ω $\pm$ 1% 1/8 W	6250-1205	75042	CEA, 2.05 k Ω $\pm$ 1%	
R231	Composition, 10 M Ω $\pm$ 5% 1/2 W	6100-6105	01121	RC20GF106J	5905-279-1865
R232	Film, 590 k Ω $\pm$ 1% 1/2 W	6193-3590	75042	MEC, 590 k Ω $\pm$ 1%	
R233	Film, 2.7 k Ω $\pm$ 1% 1/8 W	6250-1270	75042	CEA, 2.7 k Ω $\pm$ 1%	
R234	Film, 590 k Ω $\pm$ 1% 1/2 W	6193-3590	75042	MEC, 590 k Ω $\pm$ 1%	
R235	Film, 2.37 k Ω $\pm$ 1% 1/8 W	6250-1237	75042	CEA, 2.37 k Ω $\pm$ 1%	
R236	Film, 590 k Ω $\pm$ 1% 1/2 W	6193-3590	75042	CEA, 590 k Ω $\pm$ 1%	
R237	Film, 1.5 k Ω $\pm$ 1% 1/8 W	6250-1150	75042	CEA, 1.5 k Ω $\pm$ 1%	5905-581-6913
R238	Composition, 24 k Ω $\pm$ 5% 1/2 W	6100-3245	01121	RC20GF243J	5905-279-1878
R239	Composition, 144 k Ω $\pm$ 0.05% 1 W	6983-6001	24655	6983-6001	
R240	Potentiometer, wire wound 500 Ω $\pm$ 10%	6051-1509	02260	2600-PC, 500 Ω $\pm$ 10%	
R242	Composition, 15.20 k Ω $\pm$ 0.025% 1 W	6983-5004	24655	6983-5004	
R243	Composition, 72 k Ω $\pm$ 0.025% 1 W	6983-5009	24655	6983-5009	
R244	Composition, 62 k Ω $\pm$ 5% 1/2 W	6100-3625	01121	RC20GF623J	5905-249-3656

ELECTRICAL PARTS LIST (cont)

Ref. No.	Description	Part No.	Fed. Mfg. Code	Mfg. Part Code	Fed. Stock No.
RESISTORS (Cont)					
R245	Potentiometer, wire wound 5 k Ω $\pm$ 10%	6051-2509	02260	2600-PC, 5 k Ω $\pm$ 10%	
R246	Composition, 207 k Ω $\pm$ 0.05% 1 W	6983-6004	24655	6983-6004	
R247	Composition, 144 k Ω $\pm$ 0.05% 1 W	6983-6001	24655	6983-6001	
R248	Potentiometer, wire wound 500 Ω $\pm$ 10%	6051-1509	02260	2600-PC, 500 Ω $\pm$ 10%	
R249	Composition, 15.20 k Ω $\pm$ 0.025% 1 W	6983-5004	24655	6983-5004	
R250	Composition, 72 k Ω $\pm$ 0.025% 1 W	6983-5009	24655	6983-5009	
R251	Composition, 9.55 k Ω $\pm$ 0.025% 1 W	6983-4006	24655	6983-4006	
R252	Film, 1 M Ω $\pm$ 1% 1/2 W	6450-4100	75042	CEC, 1 M Ω $\pm$ 1%	5905-539-4565
R253	Composition, 1 M Ω $\pm$ 5% 1/2 W	6100-5105	01121	RC20GF105J	5905-192-0390
R254	Composition, 57 k Ω $\pm$ 0.025% 1 W	6983-5007	24655	6983-5007	
R255	Composition, 240 k Ω $\pm$ 5% 1/2 W	6100-4245	01121	RC20GF244J	5905-279-2521
R256	Composition, 240 k Ω $\pm$ 5% 1/2 W	6100-4245	01121	RC20GF244J	5905-279-2521
R257	Composition, 1 M Ω $\pm$ 5% 1/2 W	6100-5105	01121	RC20GF105J	5905-192-0390
R258	Film, 1 M Ω $\pm$ 1% 1/2 W	6450-4100	75042	CEC, 1 M Ω $\pm$ 1%	5905-539-4565
R259	Film, 1.96 M Ω $\pm$ 1% 1/2 W	6450-4196	75042	CEC, 1.96 M Ω $\pm$ 1%	
R260	Composition, 10 k Ω $\pm$ 5% 1/2 W	6100-3105	01121	RC20GF103J	5905-185-8510
R261	Potentiometer, wire wound, 500 Ω $\pm$ 10%	6051-1509	02660	2600-PC, 500 Ω $\pm$ 10%	
R262	Composition, 3.3 k Ω $\pm$ 5% 1/2 W	6100-2335	01121	RC20GF332J	5905-279-3506
R263	Composition, 33 k Ω $\pm$ 5% 1/2 W	6100-3335	01121	RC20GF333J	5905-171-1998
R264	Composition, 27 k Ω $\pm$ 5% 1/2 W	6100-3275	01121	RC20GF273J	5905-279-3499
R265	Composition, 3.3 k Ω $\pm$ 5% 1/2 W	6100-2335	01121	RC20GF332J	5905-279-3506
R266	Composition, 33 k Ω $\pm$ 5% 1/2 W	6100-3335	01121	RC20GF333J	5905-171-1998
R267	Composition, 27 k Ω $\pm$ 5% 1/2 W	6100-3275	01121	RC20GF273J	5905-279-3499
R268	Composition, 6.8 k Ω $\pm$ 5% 1/2 W	6100-2685	01121	RC20GF682J	5905-279-3503
R270	Composition, 100 k Ω $\pm$ 5% 1/2 W	6100-4105	01121	RC20GF104J	5905-195-6761
R271	Composition, 120 k Ω $\pm$ 5% 1/2 W	6100-4125	01121	RC20GF124J	5905-192-3981
R272	Composition, 82 k Ω $\pm$ 5% 1/2 W	6100-3825	01121	RC20GF823J	5905-279-3494
R273	Composition, 240 k Ω $\pm$ 5% 1/2 W	6100-4245	01121	RC20GF244J	5905-279-2521
R274	Composition, 33 k Ω $\pm$ 5% 1/2 W	6100-3335	01121	RC20GF333J	5905-171-1998
TRANSISTORS					
Q201	Type 2N1304	8210-1304	01295	2N1304	5961-892-0800
Q202	Type 2N2188	8210-1045	01295	2N2188	5960-065-5373
Q203	Type 2N1305	8210-1305	96214	2N1305	5961-853-1079
Q204 thru Q206	Type 2N910	8210-1037	24454	2N910	
Q207	Type 2N1302	8210-1018	96214	2N1302	5960-086-0039
Q208	Type 2N910	8210-1037	24454	2N910	
Q209	Type 2N910	8210-1037	24454	2N910	
Q210	Type 2N1304	8210-1304	01295	2N1304	5961-892-0800
MISCELLANEOUS					
J201	JACK	1820-2721			
J202	JACK	1820-2721			
PL201	PLUG	1820-0300			
PL202	PLUG	1820-0300			

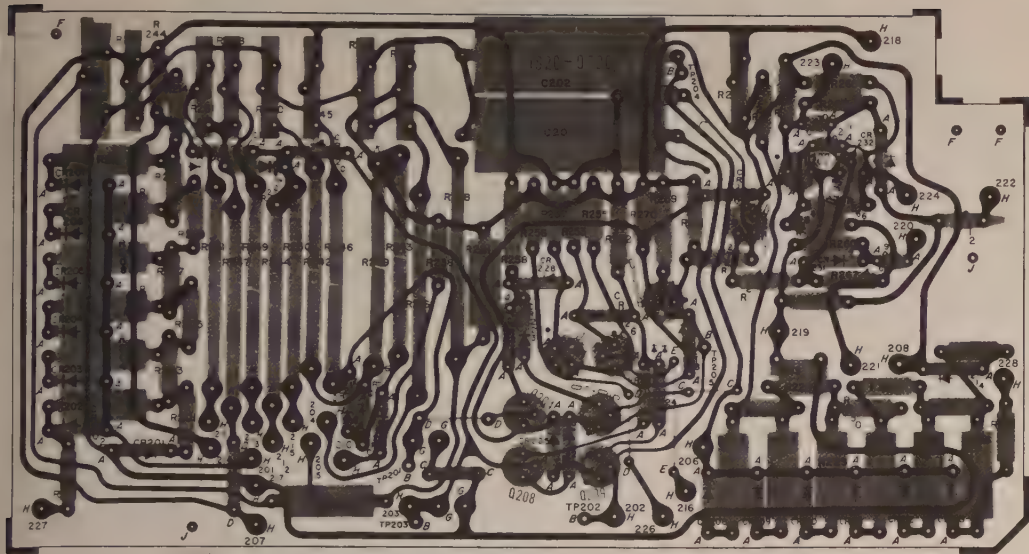


Figure 6-4a. Sweep-and-Comparator Etched-Board Assembly (P/N 1820-2721).

NOTE: The number appearing on the foil side is not the part number.
The dot on the foil at the transistor socket indicates the collector lead.

TABLE 6-2
Sweep-and-Comparator Etched-Board Assembly
(P/N 1820-2721)
Connections

Anchor Terminal	Wire Color	Signal	Immediate Connection	Destination (Origin)	Anchor Terminal
201	rd-wh-bk	-DC AMP OUTPUT	S901, 103F	- Comparator (LIN)	202**
202	wh-or-gy-br	-DC AMP OUTPUT	S901, 7	(DC Amplifier)	113*
203	rd-wh	- SLOPE BIAS	S901, 104F	(Slope Adj. Cont.)	204, 205**
204	rd-wh-or	LIN - SLOPE BIAS	S901, 106F	- Comparator	203**
205	rd-wh-ye	dB - SLOPE BIAS	S901, 105F	- Comparator	203**
206	wh-or-rd-br	DC AMP OUTPUT	AT112	(DC Amplifier)	
207	wh-or	-100-V BIAS	AT514	(Power Supply)	
208	bk	GND			
210	wh-or-gy-gn	START + SWEEP	AT354	(Start-Swp FF)	
211	rd-wh-bu	dB F-S ADJ	S901, 111F	Ground (LOG)	**
212	rd-wh-vt	-SWEEP	S901, 108F	(-100-V Bias)	207**
213	rd-wh-gy	- F-S ADJ	S901, 112F	Ground (LIN)	**
214	wh-or-gy-rd	START - SWEEP	AT356	(Start Swp FF)	
215	rd-wh-br-bk	- SWEEP	S901, 109F	(-100-V Bias)	207**
216	wh-or-vt-bn	ENABLE - COMP	AT704	(Polarity FF)	
217	bk	GND			
218	rd	+100-V BIAS	AT503	(Power Supply)	
219	wh-gy	+10-V BIAS	AT413	(2ND DCU Bias)	
220	wh-ye	WRONG POL SET	AT739	(0000 And Gate)	
221	wh-gn	+15-V BIAS	AT504	(Power Supply)	
222	gn	CLEAR PULSE	AT608	(Clear Driver)	
223	bl	COUNT SIG	AT351	(Control FF)	
			AT864	10-ms One-Shot	
224	wh-or-gy-bk	STOP COUNT	AT353	Counting Gate	
226	wh-gy-rd-br	ENABLE + COMP	AT702	(Polarity FF)	
227	rd	+100-V BIAS	AT503	(Power Supply)	
228	wh-or	-100-V BIAS	AT514	(Power Supply)	

*Connections to these points are made via the Plug-In. Refer to the Plug-In socket diagram for intermediate connections.
**Connections to these points are made via the FUNCTION switch, S901. Refer to the Sweep-and-Comparator circuit diagram (Figure 6-4b) to see the effects of the setting of S901 on these connections.

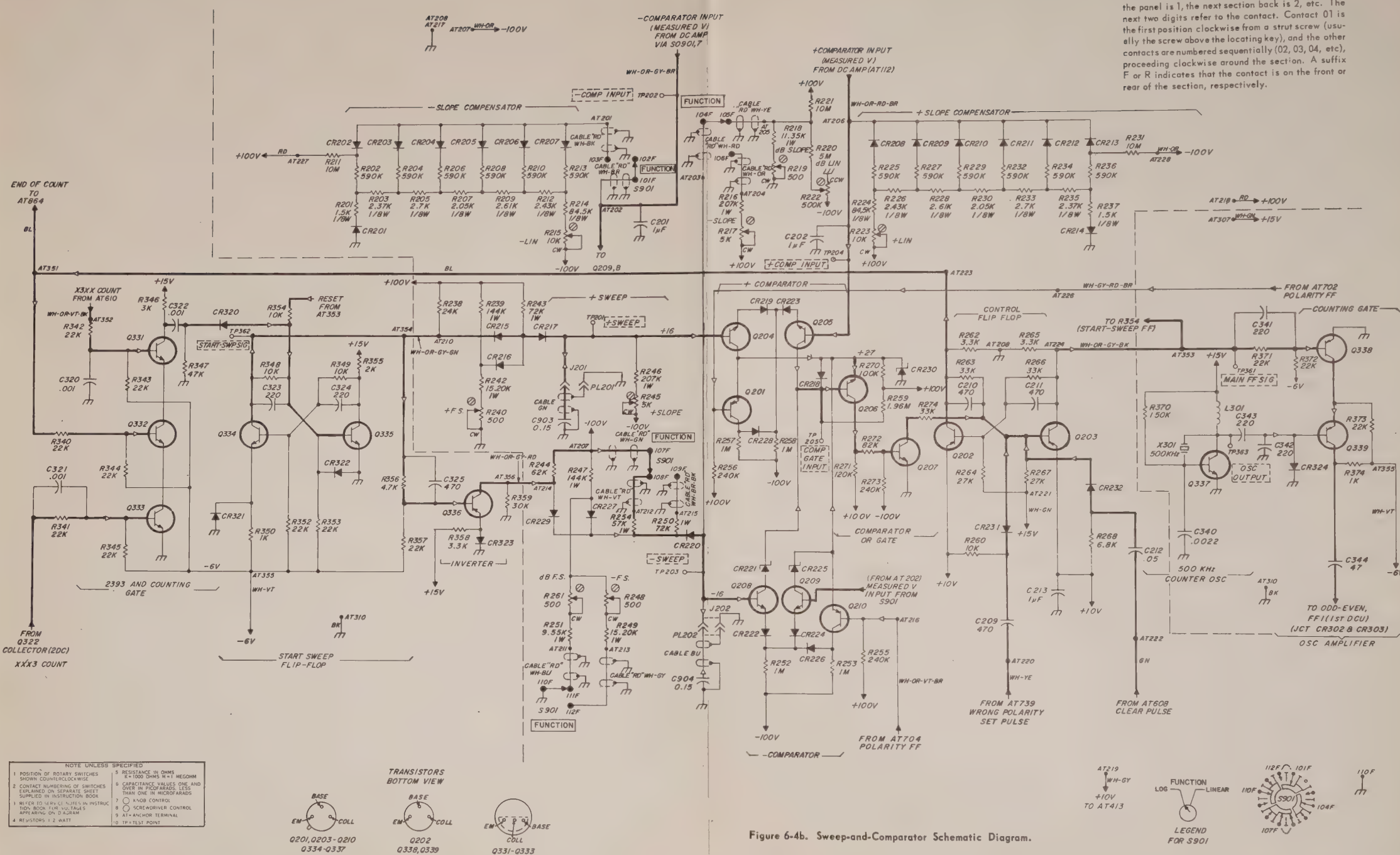


Figure 6-4b. Sweep-and-Comparator Schematic Diagram.

Rotary switch sections are shown as viewed from the panel end of the shaft. The first digit of the contact number refers to the section. The section nearest the panel is 1, the next section back is 2, etc. The next two digits refer to the contact. Contact 01 is the first position clockwise from a strut screw (usually the screw above the locating key), and the other contacts are numbered sequentially (02, 03, 04, etc), proceeding clockwise around the section. A suffix F or R indicates that the contact is on the front or rear of the section, respectively.

ELECTRICAL PARTS LIST

Ref. No.	Description	Part No.	Fed. Mfg. Code	Mfg. Part No.	Fed. Stock No.
CAPACITORS					
C301	Mica, 150 pF ±10% 500 V	4620-1050	72136	CM15, 150 pF ±10%	
C302	Mica, 150 pF ±10% 500 V	4620-1050	72136	CM15, 150 pF ±10%	
C303	Ceramic, 68 pF ±10% 500 V	4404-0688	72982	831, 68 pF ±10%	
C304	Ceramic, 220 pF ±5% 500 V (N3300)	4420-1225	72982	801, 220 pF ±5%	
C305 thru C309	Ceramic, 470 pF ±5% 500 V (N3300)	4420-1475	72982	811, 470 pF ±5%	
C310	Ceramic, 1 µF ±20% 25 V	4400-2070	80183	5C13, 1 µF ±20%	
C311	Ceramic, 1 µF ±20% 25 V	4400-2070	80183	5C13, 1 µF ±20%	
C312	Electrolytic, 3.3 µF ±20% 15 V	4450-4600	56289	150D335X0015A2	5910-837-9325
C320	Plastic, 0.001 µF ±10% 200 V	4860-7309	84411	663UW, 0.001 µF ±10%	
C321	Ceramic, 0.001 µF +80-20% 500 V	4404-2109	72982	831, 0.001 µF +80-20%	5910-983-9994
C322	Plastic, 0.001 µF ±10% 200 V	4860-7309	84411	663UW, 0.001 µF ±10%	
C323	Ceramic, 220 pF ±10% 500 V	4404-1228	72982	831, 220 pF ±10%	
C324	Ceramic, 220 pF ±10% 500 V	4404-1228	72982	831, 220 pF ±10%	
C325	Ceramic, 470 pF ±10% 500 V	4404-1478	72982	831, 470 pF ±10%	
C340	Ceramic, 0.0022 µF ±10% 500 V	4406-2228	72982	811, 0.0022 µF ±10%	
C341	Ceramic, 220 pF ±10% 500 V	4404-1228	72982	831, 220 pF ±10%	
C342	Ceramic, 220 pF ±10% 500 V	4404-1228	72982	831, 220 pF ±10%	
C343	Ceramic, 220 pF ±10% 500 V	4404-1228	72982	831, 220 pF ±10%	
C344	Ceramic, 47 pF ±10% 500 V	4404-0478	72982	831, 47 pF ±10%	
DIODES					
CR301	Type 1N3253	6081-1001	79089	1N3253	5961-814-4251
CR302 thru CR304	Type 1N3604	6082-1001	24446	1N3604	5960-995-2199
CR305 thru CR310	Type 1N4009	6082-1012	24446	1N4009	
CR311	Type 1N645	6082-1016	24446	1N645	5961-944-8222
CR320	Type 1N4009	6082-1012	24446	1N4009	
CR321	Type 1N645	6082-1016	24446	1N645	5961-944-8222
CR322	Type 1N4009	6082-1012	24446	1N4009	
CR323	Type 1N645	6082-1016	24446	1N645	5961-944-8222
CR324	Type 1N4009	6082-1012	24446	1N4009	
RESISTORS					
R301	Composition, 1 kΩ ±5% 1/2 W	6100-2105	01121	RC20GF102J	5905-195-6806
R302	Composition, 330 Ω ±5% 1/2 W	6100-1335	01121	RC20GF331J	5905-192-3971
R303	Composition, 330 Ω ±5% 1/2 W	6100-1335	01121	RC20GF331J	5905-192-3971
R304	Composition, 1 kΩ ±5% 1/2 W	6100-2105	01121	RC20GF102J	5905-195-6806
R305	Composition, 10 kΩ ±5% 1/2 W	6100-3105	01121	RC20GF103J	5905-185-8510
R306 thru R315	Composition, 1 kΩ ±5% 1/2 W	6100-2105	01121	RC20GF102J	5905-195-6806
R316	Composition, 15 kΩ ±5% 1/2 W	6100-3155	01121	RC20GF153J	5905-279-2616
R317	Composition, 15 kΩ ±5% 1/2 W	6100-3155	01121	RC20GF153J	5905-279-2616
R318	Composition, 1 kΩ ±5% 1/2 W	6100-2105	01121	RC20GF102J	5905-195-6806
R319	Composition, 47 kΩ ±5% 1/2 W	6100-3475	01121	RC20GF473J	5905-254-9201
R320	Composition, 47 kΩ ±5% 1/2 W	6100-3475	01121	RC20GF473J	5905-254-9201
R321	Composition, 7.5 kΩ ±5% 1/2 W	6100-2755	01121	RC20GF752J	5905-249-4195
R322	Composition, 15 kΩ ±5% 1/2 W	6100-3155	01121	RC20GF153J	5905-279-2616
R323	Composition, 10 kΩ ±5% 1/2 W	6100-3105	01121	RC20GF103J	5905-185-8510
R324	Composition, 750 Ω ±5% 1/2 W	6100-1755	01121	RC20GF751J	5905-195-9481
R325	Composition, 10 kΩ ±5% 1/2 W	6100-3105	01121	RC20GF103J	5905-185-8510
R326	Composition, 680 Ω ±5% 1/2 W	6100-1685	01121	RC20GF681J	5905-195-6791
R327	Composition, 750 Ω ±5% 1/2 W	6100-1755	01121	RC20GF751J	5905-195-9481
R328	Composition, 750 Ω ±5% 1/2 W	6100-1755	01121	RC20GF751J	5905-195-9481
R329	Composition, 10 kΩ ±5% 1/2 W	6100-3105	01121	RC20GF103J	5905-185-8510
R330	Composition, 750 Ω ±5% 1/2 W	6100-1755	01121	RC20GF751J	5905-195-9481
R331	Composition, 10 kΩ ±5% 1/2 W	6100-3105	01121	RC20GF103J	5905-185-8510
R332	Composition, 10 kΩ ±5% 1/2 W	6100-3105	01121	RC20GF103J	5905-185-8510
R333	Composition, 750 Ω ±5% 1/2 W	6100-1755	01121	RC20GF751J	5905-195-9481
R334	Composition, 10 kΩ ±5% 1/2 W	6100-3105	01121	RC20GF103J	5905-185-8510
R335	Composition, 5.1 kΩ ±5% 1/2 W	6100-2515	01121	RC20GF512J	5905-279-2019
R336	Composition, 10 kΩ ±5% 1/2 W	6100-3105	01121	RC20GF103J	5905-185-8510
R337	Composition, 51 kΩ ±5% 1/2 W	6100-3515	01121	RC20GF513J	5905-279-3496
R338	Composition, 51 kΩ ±5% 1/2 W	6100-3515	01121	RC20GF513J	5905-279-3496
R340 thru R345	Composition, 22 kΩ ±5% 1/2 W	6100-3225	01121	RC20GF223J	5905-171-2004

ELECTRICAL PARTS LIST (cont)

Ref. No.	Description	Part No.	Fed. Mfg. Code	Mfg. Part No.	Fed. Stock No.
RESISTORS (Cont)					
R346	Composition, 3 kΩ ±5% 1/2 W	6100-2305	01121	RC20GF302J	5905-279-1751
R347	Composition, 47 kΩ ±5% 1/2 W	6100-3475	01121	RC20GF473J	5905-254-9201
R348	Composition, 10 kΩ ±5% 1/2 W	6100-3105	01121	RC20GF103J	5905-185-8510
R349	Composition, 10 kΩ ±5% 1/2 W	6100-3105	01121	RC20GF103J	5905-185-8510
R350	Composition, 1 kΩ ±5% 1/2 W	6100-2105	01121	RC20GF102J	5905-195-6806
R352	Composition, 22 kΩ ±5% 1/2 W	6100-3225	01121	RC20GF223J	5905-171-2004
R353	Composition, 22 kΩ ±5% 1/2 W	6100-3225	01121	RC20GF223J	5905-171-2004
R354	Composition, 10 kΩ ±5% 1/2 W	6100-3105	01121	RC20GF103J	5905-185-8510
R355	Composition, 2 kΩ ±5% 1/2 W	6100-2205	01121	RC20GF202J	5905-190-8887
R356	Composition, 4.7 kΩ ±5% 1/2 W	6100-2475	01121	RC20GF472J	5905-279-3504
R357	Composition, 22 kΩ ±5% 1/2 W	6100-3225	01121	RC20GF223J	5905-171-2004
R358	Composition, 3.3 kΩ ±5% 1/2 W	6100-2335	01121	RC20GF332J	5905-279-3506
R359	Composition, 30 kΩ ±5% 1/2 W	6100-3305	01121	RC20GF303J	5905-192-3978
R370	Composition, 150 kΩ ±5% 1/2 W	6100-4155	01121	RC20GF154J	5905-279-2522
R371	Composition, 22 kΩ ±5% 1/2 W	6100-3225	01121	RC20GF223J	5905-171-2004
R372	Composition, 22 kΩ ±5% 1/2 W	6100-3225	01121	RC20GF223J	5905-171-2004
R373	Composition, 22 kΩ ±5% 1/2 W	6100-3225	01121	RC20GF223J	5905-171-2004
R374	Composition, 1 kΩ ±5% 1/2 W	6100-2105	01121	RC20GF102J	5905-195-6806
TRANSISTORS					
Q301	Type 2N697	8210-1040	82219	2N697	5961-752-0150
Q302	Type 2N697	8210-1040	82219	2N697	5961-752-0150
Q303 thru Q312	Type 2N3416	8210-1047	24446	2N3414	5961-989-2749
Q313	Type 2N1499B	8210-1068	56289	2N1499B	
Q314	Type 2N1499B	8210-1068	56289	2N1499B	
Q315	Type 2N2218	8210-1028	81349	2N2218	5960-059-4464
Q316	Type 2N1499B	8210-1068	56289	2N1499B	
Q317	Type 2N1304	8210-1304	01295	2N1304	5961-892-0800
Q318	Type 2N1499B	8210-1068	56289	2N1499B	
Q319	Type 2N1302	8210-1018	96214	2N1302	5960-086-0039
Q320	Type 2N1499B	8210-1068	56289	2N1499B	
Q321	Type 2N1302	8210-1018	96214	2N1302	5960-086-0039
Q322	Type 2N1499B	8210-1068	56289	2N1499B	
Q323	Type 2N1302	8210-1018	96214	2N1302	5960-086-0039
Q324	Type 2N1499B	8210-1068	56289	2N1499B	
Q325	Type 2N1302	8210-1018	96214	2N1302	
Q331 thru Q333	Type 2N3390	8210-1077	24454	2N3390	
Q334	Type 2N697	8210-1040	82219	2N697	5961-752-0150
Q335	Type 2N697	8210-1040	82219	2N697	5961-752-0150
Q336	Type 2N1377	8210-1377	96214	2N1377	5960-950-3449
Q337	Type 2N697	8210-1040	82219	2N697	5961-752-0150
Q338	Type 2N2188	8210-1045	01295	2N2188	5960-065-5373
Q339	Type 2N2188	8210-1045	01295	2N2188	5960-065-5373
MISCELLANEOUS					
X301	CRYSTAL	1520-0490	24655	1520-0490	
L301	INDUCTOR, 10 mH ±10%	4300-6200	99800	3500-42	

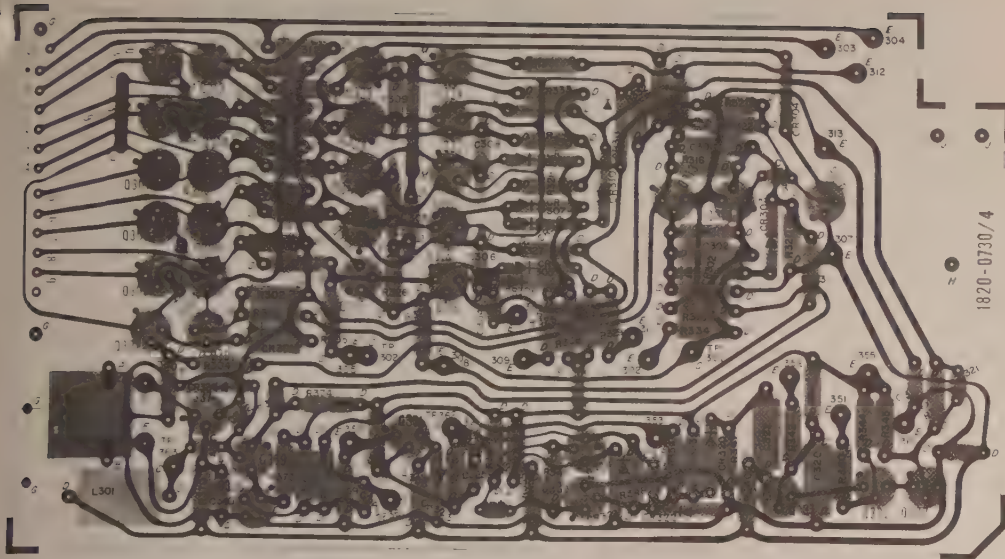


Figure 6-5a. Count-Control-and-First-DCU Etched-Board Assembly (P/N 1820-2731).

NOTE: The number appearing on the foil side is not the part number.
The dot on the foil at the transistor socket indicates the collector lead.

Anchor Terminal	Wire Color	Signal	Immediate Connection	Destination (Origin)	Anchor Terminal
302	wh-gn-br	UNITS "1"	R951, SO903, A4	DATA OUTPUT	504
303	wh-gn-bu	XXX.X DEC POINT	SO902, 1	SO902, 1 (Sig not used)	
304	gy	LAMP COMMON +15V	AT729, 604, 404	(Power Supply)	
305	wh-rd-bk	UNITS "2"	R969, SO903, G4	DATA OUTPUT	
306	wh-rd-br	1ST DCU OUTPUT	AT401	2ND DCU Input	
307	wh-gn	+15-V BIAS	AT504	(Power Supply)	
308	gn	CLEAR PULSE	AT608	(Clear Driver)	
309	wh-rd-bu	UNITS "4"	R966, SO903, E4	DATA OUTPUT	
310	bk	GND			
311	wh-rd-gn	UNITS "2"	R960, SO903, C4	DATA OUTPUT	
312	wh-gy-bu	XXX0 COUNT	AT737	0000 And Gate	
313	wh-gy	+10-V BIAS	AT413	(2ND DCU Bias)	
351	bu	COUNT SIG	AT223	(Counting Gate)	
352	wh-or-vt-bk	X3XX COUNT	AT864	10-ms One-Shot	
353	wh-or-gy-bk	STOP COUNT	AT610	(3RD DCU)	
354	wh-or-gy-gn	START + SWEEP	AT224	(Control FF)	
355	wh-vt	-6-V BIAS	AT210	+ Sweep Circuit	
356	wh-or-gy-rd	START - SWEEP	AT509	(Power Supply)	
			AT214	Inverter	

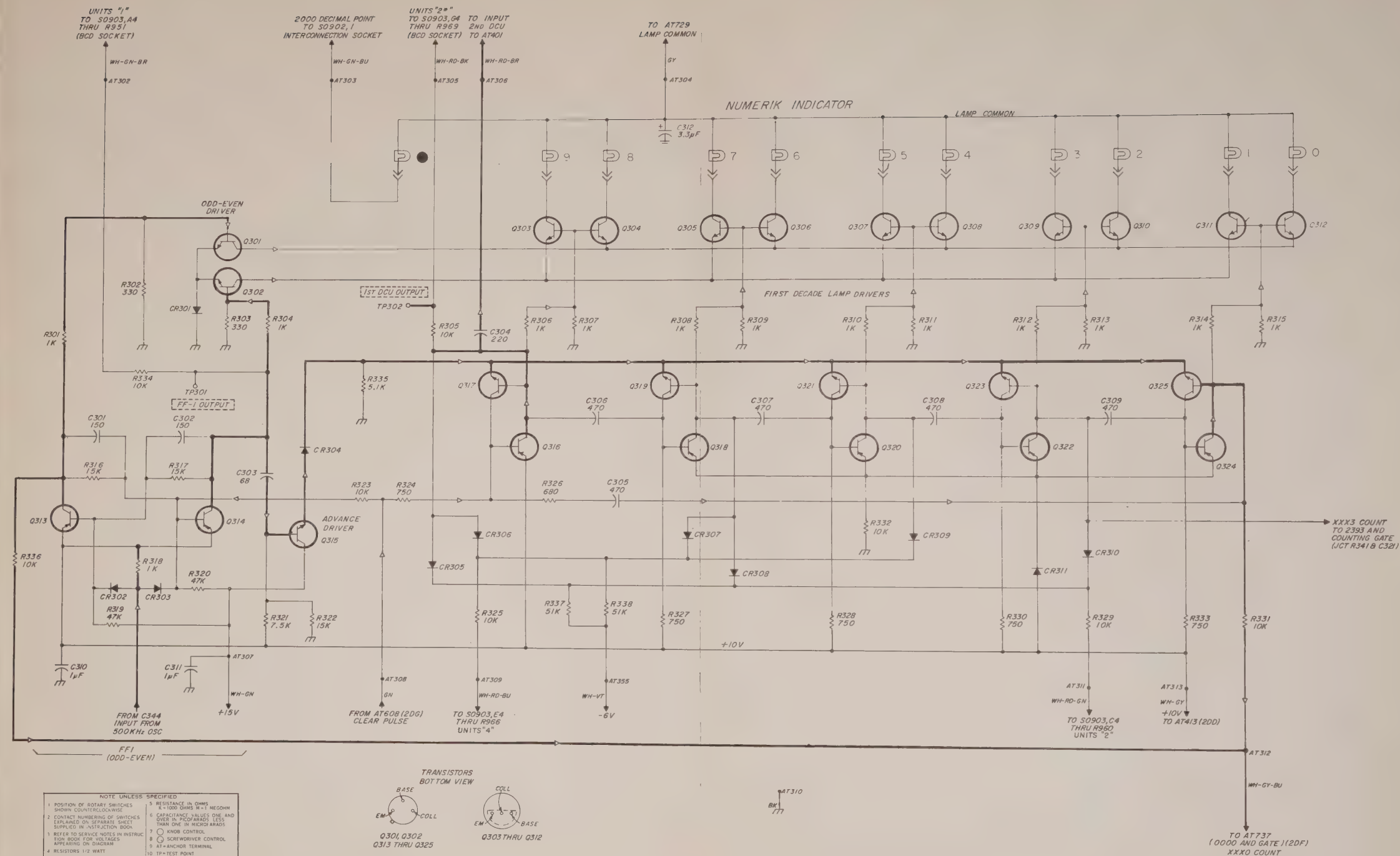


Figure 6-5b. Count-Control-and-First-DCU Schematic Diagram.

ELECTRICAL PARTS LIST

Ref. No.	Description	Part No.	Fed. Mfg. Code	Mfg. Part No.	Fed. Stock No.
CAPACITORS					
C401	Mica, 330 pF $\pm 10\%$ 300 V	4620-1330	72136	CM15, 330 pF $\pm 10\%$	
C402	Mica, 330 pF $\pm 10\%$ 300 V	4620-1330	72136	CM15, 330 pF $\pm 10\%$	
C403	Ceramic, 470 pF $\pm 10\%$ 500 V	4404-1478	72982	831, 470 pF $\pm 10\%$	
C404	Ceramic, 220 pF $\pm 5\%$ (N3300)	4420-1225			
C405 thru C409	Ceramic, 0.0047 μ F $\pm 10\%$ 500 V	4407-2478	72982	841, 0.0047 μ F $\pm 10\%$	5910-931-0529
C410	Ceramic, 1 μ F $\pm 20\%$ 25 V	4400-2070	80183	5C13, 1 μ F $\pm 10\%$	
C411	Electrolytic, 3.3 μ F $\pm 20\%$ 15 V	4450-4600	56289	150D335X0015A2	5910-837-9325
DIODES					
CR401	Type 1N3253	6081-1001	79089	1N3253	5961-814-4251
CR402	Type 1N4009	6082-1012	24446	1N4009	
CR403	Type 1N4009	6082-1012	24446	1N4009	
CR405 thru CR410	Type 1N4009	6082-1012	24446	1N4009	
CR411	Type 1N645	6082-1016	24446	1N645	5961-944-8222
CR431	Type 1N748A 3.9 V $\pm 5\%$ 0.4 W	6083-1002	07910	1N748A	5960-800-3973
CR432	Type 1N645	6082-1016	24446	1N645	5961-944-8222
RESISTORS					
R401	Composition, 1 k Ω $\pm 5\%$ 1/2 W	6100-2105	01121	RC20GF102J	5905-195-6806
R402	Composition, 330 Ω $\pm 5\%$ 1/2 W	6100-1335	01121	RC20GF331J	5905-192-3971
R403	Composition, 330 Ω $\pm 5\%$ 1/2 W	6100-1335	01121	RC20GF331J	5905-192-3971
R404	Composition, 1 k Ω $\pm 5\%$ 1/2 W	6100-2105	01121	RC20GF102J	5905-195-6806
R405	Composition, 10 k Ω $\pm 5\%$ 1/2 W	6100-3105	01121	RC20GF103J	5905-185-8510
R406 thru R415	Composition, 1 k Ω $\pm 5\%$ 1/2 W	6100-2105	01121	RC20GF102J	5905-195-6806
R416	Composition, 15 k Ω $\pm 5\%$ 1/2 W	6100-3155	01121	RC20GF153J	5905-279-2616
R417	Composition, 15 k Ω $\pm 5\%$ 1/2 W	6100-3155	01121	RC20GF153J	5905-279-2616
R418	Composition, 1 k Ω $\pm 5\%$ 1/2 W	6100-2105	01121	RC20GF102J	5905-195-6806
R419	Composition, 22 k Ω $\pm 5\%$ 1/2 W	6100-3225	01121	RC20GF223J	5905-171-2004
R420	Composition, 22 k Ω $\pm 5\%$ 1/2 W	6100-3225	01121	RC20GF223J	5905-171-2004
R421	Composition, 7.5 k Ω $\pm 5\%$ 1/2 W	6100-2755	01121	RC20GF752J	5905-249-4195
R422	Composition, 15 k Ω $\pm 5\%$ 1/2 W	6100-3155	01121	RC20GF153J	5905-279-2616
R423	Composition, 10 k Ω $\pm 5\%$ 1/2 W	6100-3105	01121	RC20GF103J	5905-185-8510
R424	Composition, 750 Ω $\pm 5\%$ 1/2 W	6100-1755	01121	RC20GF751J	5905-195-9481
R425	Composition, 10 k Ω $\pm 5\%$ 1/2 W	6100-3105	01121	RC20GF103J	5905-185-8510
R426	Composition, 680 Ω $\pm 5\%$ 1/2 W	6100-1685	01121	RC20GF681J	5905-195-6791
R427	Composition, 750 Ω $\pm 5\%$ 1/2 W	6100-1755	01121	RC20GF751J	5905-195-9481
R428	Composition, 750 Ω $\pm 5\%$ 1/2 W	6100-1755	01121	RC20GF751J	5905-195-9481
R429	Composition, 10 k Ω $\pm 5\%$ 1/2 W	6100-3105	01121	RC20GF103J	5905-185-8510
R430	Composition, 750 Ω $\pm 5\%$ 1/2 W	6100-1755	01121	RC20GF751J	5905-195-9481
R431	Composition, 10 k Ω $\pm 5\%$ 1/2 W	6100-3105	01121	RC20GF103J	5905-185-8510
R432	Composition, 10 k Ω $\pm 5\%$ 1/2 W	6100-3105	01121	RC20GF103J	5905-185-8510
R433	Composition, 750 k Ω $\pm 5\%$ 1/2 W	6100-1755	01121	RC20GF751J	5905-195-9481
R434	Composition, 10 k Ω $\pm 5\%$ 1/2 W	6100-3105	01121	RC20GF103J	5905-185-8510
R435	Composition, 3.3 k Ω $\pm 5\%$ 1/2 W	6100-2335	01121	RC20GF332J	5905-279-3506
R436	Composition, 10 k Ω $\pm 5\%$ 1/2 W	6100-3105	01121	RC20GF103J	5905-185-8510
R437	Composition, 100 Ω $\pm 5\%$ 1/2 W	6100-1105	01121	RC20GF101J	5905-190-8889
R438	Composition, 51 k Ω $\pm 5\%$ 1/2 W	6100-3515	01121	RC20GF513J	5905-279-3496
R439	Composition, 51 k Ω $\pm 5\%$ 1/2 W	6100-3515	01121	RC20GF513J	5905-279-3496
R454	Wire wound, 1 Ω $\pm 10\%$ 2 W	6760-9109	75042	BWH, 1 Ω $\pm 10\%$	
TRANSISTORS					
Q401	Type 2N697	8210-1040	82219	2N697	5961-752-0150
Q402	Type 2N697	8210-1040	82219	2N697	5961-752-0150
Q403 thru Q412	Type 2N3416	8210-1047	24446	2N3414	5961-989-2749
Q413	Type 2N1303	8210-1019	96214	2N1303	
Q414	Type 2N1303	8210-1019	96214	2N1303	
Q415	Type 2N697	8210-1040	82219	2N697	5961-752-0150
Q416	Type 2N1303	8210-1019	96214	2N1303	
Q417	Type 2N1302	8210-1018	96214	2N1302	5960-086-0039
Q418	Type 2N1303	8210-1019	96214	2N1303	
Q419	Type 2N1302	8210-1018	96214	2N1302	5960-086-0039
Q420	Type 2N1303	8210-1019	96214	2N1303	
Q421	Type 2N1302	8210-1018	96214	2N1302	
Q422	Type 2N1303	8210-1019	96214	2N1303	
Q423	Type 2N1302	8210-1018	96214	2N1302	
Q424	Type 2N1303	8210-1019	96214	2N1303	
Q425	Type 2N1302	8210-1018	96214	2N1302	5960-086-0039

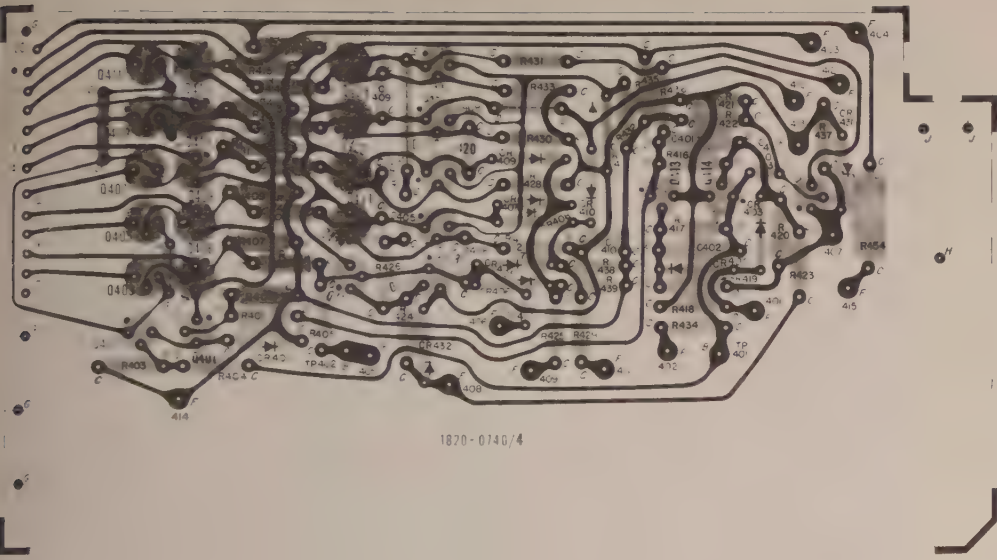


Figure 6-6a. Second-DCU Etched-Board Assembly (P/N 1820-2761).

NOTE: The number appearing on the foil side is not the part number.
The dot on the foil at the transistor socket indicates the collector lead.

Anchor Terminal	Wire Color	Signal	Immediate Connection	Destination (Origin)	Anchor Terminal
401	wh-rd-br	1ST DCU OUTPUT	AT306	1ST DCU	726** 504
402	wh-gy-br	TENS "1"	R956, SO903, B3	DATA OUTPUT ("4, 5, 6" Driver)	
403	wh-ye-rd	XXX.X DEC POINT	S901, 306F	(Power Supply)	407
404	gy	LAMP COMMON +15 V	AT729, 304, 604	DATA OUTPUT	
405	wh-gy-gn	TENS "2"	R970, SO903, H3	3RD DCU Input	
406	wh-gy-rd	2ND DCU OUTPUT	AT601	(Power Supply)	
407	wh-gn	+15-V BIAS	AT504	(Clear Driver)	
408	gn	CLEAR PULSE	AT608	DATA OUTPUT	
409	wh-vt-bk	TENS "4"	R967, SO903, F3	DATA OUTPUT	
411	wh-vt-br	TENS "2"	R964, SO903, D3	0000 And Gate	
412	wh-vt-br-bk	XXOX COUNT	AT736	(Power Supply via CR431, R437)	
413	wh-gy	+10-V BIAS	AT219, 313, 613 710, 810 R962, SO903, C12	DATA OUTPUT	
414	bk	GND	AT504	(Power Supply)	
415	wh-gn-bu-bk	+15-V LAMP SUPPLY	AT504	(Power Supply)	

** Connections to these points are made via the FUNCTION switch, S901. Refer to the Range-Control circuit diagram (Figure 6-9b) to see the effects of the setting of S901 on these connections.

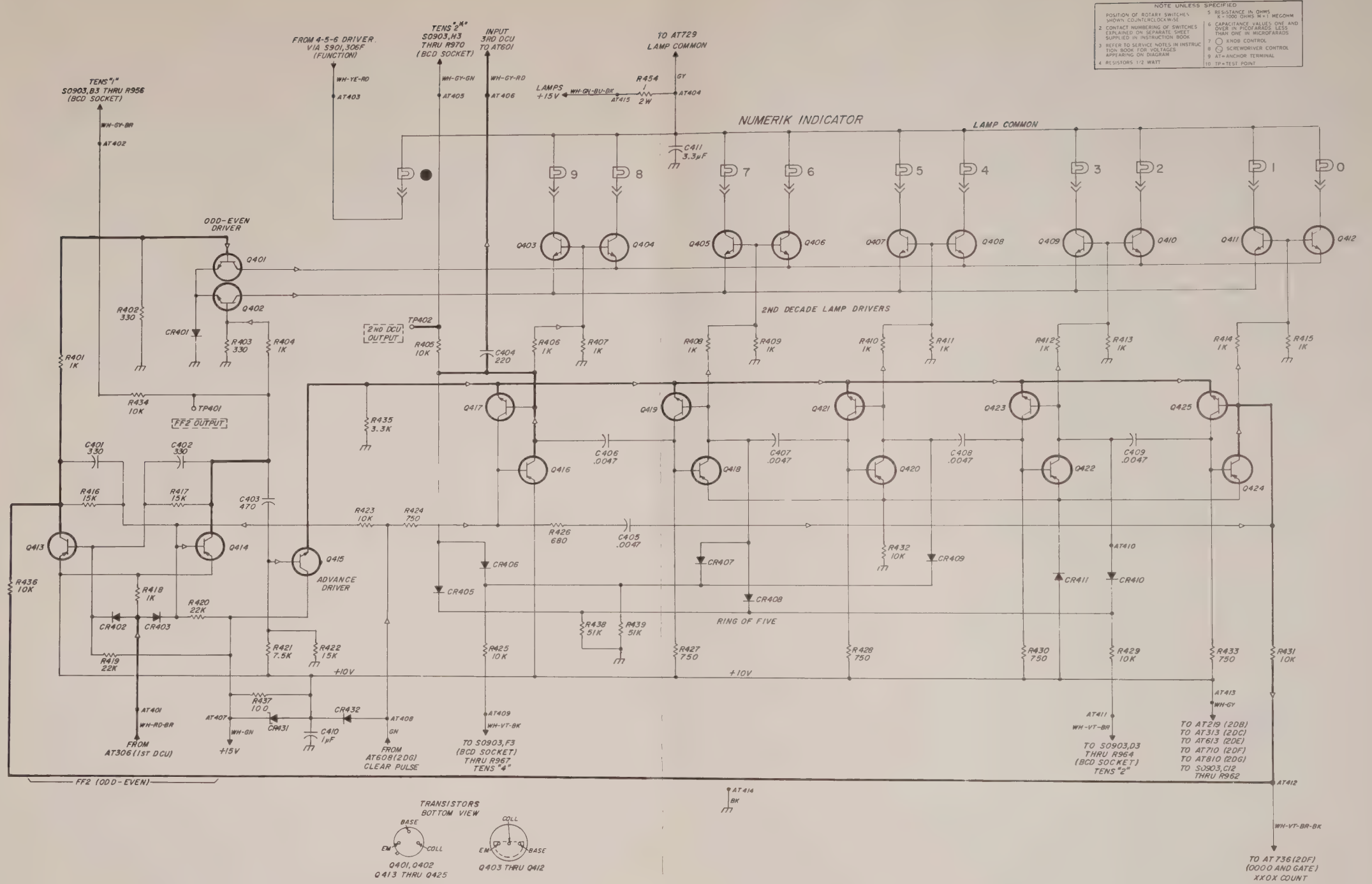


Figure 6-6b. Second-DCU Schematic Diagram.

ELECTRICAL PARTS LIST

Ref. No.	Description	Part No.	Fed. Mfg. Code	Mfg. Part No.	Fed. Stock No.
CAPACITORS					
C601	Ceramic, 0.0022 μ F $\pm$ 10% 500 V	4406-2228	72982	811, 0.0022 μ F $\pm$ 10%	
C602	Ceramic, 0.0022 μ F $\pm$ 10% 500 V	4406-2228	72982	811, 0.0022 μ F $\pm$ 10%	
C603	Ceramic, 470 pF $\pm$ 10% 500 V	4404-1478	72982	831, 470 pF $\pm$ 10%	
C604	Ceramic, 220 pF $\pm$ 5% 500 V (N3300)	4420-1225	72982	801, 220 pF $\pm$ 5%	
C605 thru C609	Ceramic, 0.0047 μ F $\pm$ 10% 500 V	4407-2478	72982	841, 0.0047 μ F $\pm$ 10%	5910-931-0529
C610	Electrolytic, 3.3 μ F $\pm$ 20% 15 V	4450-4600	56289	150D335X0015A2	5910-837-9325
C650	Ceramic, 470 pF $\pm$ 10% 500 V	4404-1478	72982	831, 470 pF $\pm$ 10%	
C651	Electrolytic, 3.3 μ F $\pm$ 20% 15 V	4450-4600	56289	150D335X0015A2	5910-837-9325
C652 thru C655	Ceramic, 0.01 μ F $\pm$ 80-20% 50 V	4401-3100	80131	CC61, 0.01 μ F $\pm$ 80-20%	5910-974-5697
DIODES					
CR601	Type 1N3253	6081-1001	79089	1N3253	5961-814-4251
CR602	Type 1N4009	6082-1012	24446	1N4009	
CR603	Type 1N4009	6082-1012	24446	1N4009	
CR605 thru CR610	Type 1N4009	6082-1012	24446	1N4009	
CR611	Type 1N645	6082-1016	24446	1N645	5961-944-8222
CR650 thru CR652	Type 1N4009	6082-1012	24446	1N4009	
CR653	Type 1N645	6082-1016	24446	1N645	5961-944-8222
CT654	Type 1N4009	6082-1012	24446	1N4009	
RESISTORS					
R601	Composition, 1 k Ω $\pm$ 5% 1/2 W	6100-2105	01121	RC20GF102J	5905-195-6806
R602	Composition, 330 Ω $\pm$ 5% 1/2 W	6100-1335	01121	RC20GF331J	5905-192-3971
R603	Composition, 330 Ω $\pm$ 5% 1/2 W	6100-1335	01121	RC20GF331J	5905-192-3971
R604	Composition, 1 k Ω $\pm$ 5% 1/2 W	6100-2105	01121	RC20GF102J	5905-195-6806
R605	Composition, 10 k Ω $\pm$ 5% 1/2 W	6100-3105	01121	RC20GF103J	5905-185-8510
R606 thru R615	Composition, 1 k Ω $\pm$ 5% 1/2 W	6100-2105	01121	RC20GF102J	5905-195-6806
R616	Composition, 15 k Ω $\pm$ 5% 1/2 W	6100-3155	01121	RC20GF153J	5905-279-2616
R617	Composition, 15 k Ω $\pm$ 5% 1/2 W	6100-3155	01121	RC20GF153J	5905-279-2616
R618	Composition, 1 k Ω $\pm$ 5% 1/2 W	6100-2105	01121	RC20GF102J	5905-195-6806
R619	Composition, 22 k Ω $\pm$ 5% 1/2 W	6100-3225	01121	RC20GF223J	5905-171-2004
R620	Composition, 22 k Ω $\pm$ 5% 1/2 W	6100-3225	01121	RC20GF223J	5905-171-2004
R621	Composition, 7.5 k Ω $\pm$ 5% 1/2 W	6100-2755	01121	RC20GF752J	5905-249-4195
R622	Composition, 15 k Ω $\pm$ 5% 1/2 W	6100-3155	01121	RC20GF153J	5905-279-2616
R623	Composition, 10 k Ω $\pm$ 5% 1/2 W	6100-3105	01121	RC20GF103J	5905-185-8510
R624	Composition, 750 Ω $\pm$ 5% 1/2 W	6100-1755	01121	RC20GF751J	5905-195-9481
R625	Composition, 10 k Ω $\pm$ 5% 1/2 W	6100-3105	01121	RC20GF103J	5905-185-8510
R626	Composition, 680 Ω $\pm$ 5% 1/2 W	6100-1685	01121	RC20GF681J	5905-195-6791
R627	Composition, 750 Ω $\pm$ 5% 1/2 W	6100-1755	01121	RC20GF751J	5905-195-9481
R628	Composition, 750 Ω $\pm$ 5% 1/2 W	6100-1755	01121	RC20GF751J	5905-195-9481
R629	Composition, 10 k Ω $\pm$ 5% 1/2 W	6100-3105	01121	RC20GF103J	5905-185-8510
R630	Composition, 750 Ω $\pm$ 5% 1/2 W	6100-1755	01121	RC20GF751J	5905-195-9481
R632	Composition, 10 k Ω $\pm$ 5% 1/2 W	6100-3105	01121	RC20GF103J	5905-185-8510
R633	Composition, 750 Ω $\pm$ 5% 1/2 W	6100-1755	01121	RC20GF751J	5905-195-9481
R634	Composition, 10 k Ω $\pm$ 5% 1/2 W	6100-3105	01121	RC20GF103J	5905-185-8510
R635	Composition, 3.3 k Ω $\pm$ 5% 1/2 W	6100-2335	01121	RC20GF332J	5905-279-3506
R636	Composition, 10 k Ω $\pm$ 5% 1/2 W	6100-3105	01121	RC20GF103J	5905-185-8510
R637	Composition, 51 k Ω $\pm$ 5% 1/2 W	6100-3515	01121	RC20GF513J	5905-279-3496
R638	Composition, 51 k Ω $\pm$ 5% 1/2 W	6100-3515	01121	RC20GF513J	5905-279-3496
R650	Composition, 62 k Ω $\pm$ 5% 1/2 W	6100-3625	01121	RC20GF623J	5905-249-3656
R651	Composition, 680 k Ω $\pm$ 5% 1/2 W	6100-4685	01121	RC20GF684J	5905-171-2000
R652	Composition, 56 k Ω $\pm$ 5% 1/2 W	6100-3565	01121	RC20GF563J	5905-171-1986
R653	Composition, 16 k Ω $\pm$ 5% 1/2 W	6100-3165	01121	RC20GF163J	5905-279-3501
R654	Composition, 330 Ω $\pm$ 5% 1/2 W	6100-1335	01121	RC20GF331J	5905-192-3971
R655	Composition, 100 Ω $\pm$ 5% 1/2 W	6100-1105	01121	RC20GF101J	5905-190-8889
R656	Composition, 10 k Ω $\pm$ 5% 1/2 W	6100-3105	01121	RC20GF103J	5905-185-8510
R657	Composition, 100 k Ω $\pm$ 5% 1/2 W	6100-4105	01121	RC20GF104J	5905-195-6761
R658 thru R660	Composition, 10 k Ω $\pm$ 5% 1/2 W	6100-3105	01121	RC20GF103J	5905-185-8510
R661	Composition, 22 k Ω $\pm$ 5% 1/2 W	6100-3225	01121	RC20GF223J	5905-171-2004

ELECTRICAL PARTS LIST (cont)

Ref. No.	Description	Part No.	Fed. Mfg. Code	Mfg. Part No.	Fed. Stock No.
RESISTORS (Cont)					
R662	Composition, 10 k Ω $\pm$ 5% 1/2 W	6100-3105	01121	RC20GF103J	5905-185-8510
R663	Composition, 330 Ω $\pm$ 5% 1/2 W	6100-1335	01121	RC20GF331J	5905-192-3971
R664	Composition, 10 k Ω $\pm$ 5% 1/2 W	6100-3105	01121	RC20GF103J	5905-185-8510
TRANSISTORS					
Q601	Type 2N697	8210-1040	82219	2N697	5961-752-0150
Q602	Type 2N697	8210-1040	82219	2N697	5961-752-0150
Q603 thru Q612	Type 2N3416	8210-1047	24446	2N3414	5961-989-2749
Q613	Type 2N1305	8210-1305	96214	2N1305	5961-853-1079
Q614	Type 2N1305	8210-1305	96214	2N1305	5961-853-1079
Q615	Type 2N697	8210-1040	82219	2N697	5961-752-0150
Q616	Type 2N1303	8210-1019	96214	2N1303	
Q617	Type 2N1302	8210-1018	96214	2N1302	5960-086-0039
Q618	Type 2N1303	8210-1019	96214	2N1303	
Q619	Type 2N1302	8210-1018	96214	2N1302	5960-086-0039
Q620	Type 2N1303	8210-1019	96214	2N1303	
Q621	Type 2N1302	8210-1018	96214	2N1302	5960-086-0039
Q622	Type 2N1303	8210-1019	96214	2N1303	
Q623	Type 2N1302	8210-1018	96214	2N1302	5960-086-0039
Q624	Type 2N1303	8210-1019	96214	2N1303	
Q625	Type 2N1302	8210-1018	96214	2N1302	5960-086-0039
Q650	Type 2N697	8210-1040	82219	2N697	5961-752-0150
Q651	Type 2N1671B	8210-1026	96214	2N1671B	
Q652	Type 2N1303	8210-1019	96214	2N1303	
Q653	Type 2N1303	8210-1019	96214	2N1303	
Q654	Type 2N1304	8210-1304	01295	2N1304	5961-892-0800

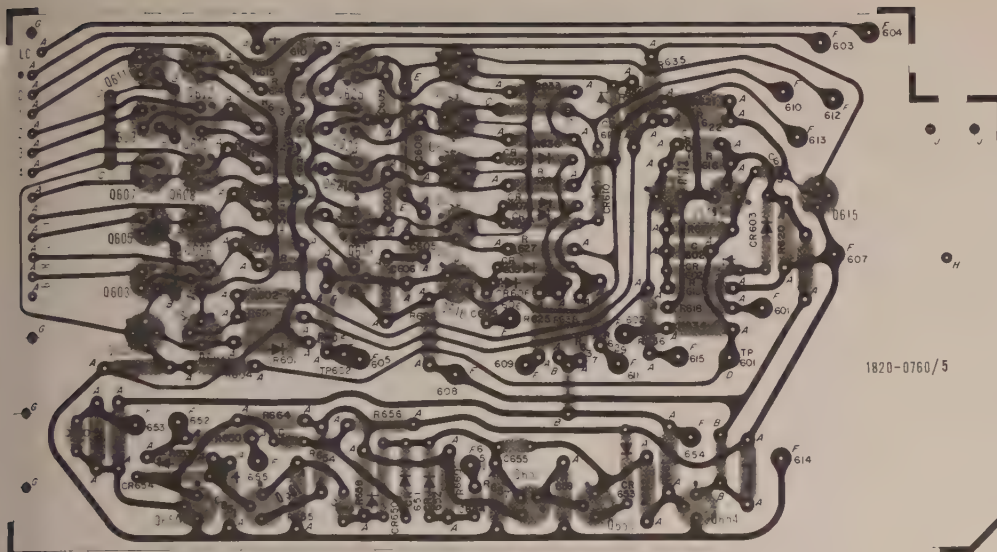


Figure 6-7a. Third-DCU-and-Sampling-Control Etched-Board Assembly (P/N 1820-2761).

NOTE: The number appearing on the foil side is not the part number.
The dot on the foil at the transistor socket indicates the collector lead.

Anchor Terminal	Wire Color	Signal	Immediate Connection	Destination (Origin)	Anchor Terminal
601	wh-gy-rd	2ND DCU OUTPUT	AT406	(2ND DCU)	
602	wh-gy-bk	HUNDS "1"	R950, SO903, A2	DATA OUTPUT	
603	wh-ye-bu	XX.XX DEC POINT	S901, 303F	"2-3-4" DRIVE	
604	gy	LAMP COMMON +15 V	AT729, 304, 404	(Power Supply)	
605	or	HUNDS "2"	R968, SO903, G2	DATA OUTPUT	
606	wh-br-bk	3RD DCU OUTPUT	AT712	MSD Ring of 3	
607	wh-gn	+15-V BIAS	AT504	(Power Supply)	
608	gn	CLEAR PULSE	AT222, 308, 408, 713, 865	Control FF; 1ST, 2ND 3RD DCU; MSD Ring of 3; Print-Command FF	
609	wh-bu-bk	HUNDS "4"	R695, SO903, E2	DATA OUTPUT	
610	wh-or-vt-bk	X3XX	AT352	2393 And Gate	
611	wh-bu-br	HUNDS "2"	R959, SO903, C2	DATA OUTPUT	
612	wh-gn-bk	X0XX or X1XX	AT738, 852	0000 And Gate, Range Gates	
613	wh-gy	+10-V BIAS	AT413	(2ND DCU Bias)	
614	bk	GND			
615	wh-vt-br-bk	X0XX (EVEN)	AT736	0000 And Gate	
651	br	EXT SAMP	SO903, E12	DATA OUTPUT	
	wh-vt-gn-bu	EXT SAMP	SO904, 3	(External Sampling Rate Gen)	
652	wh-gy-gn-br	INT SAMP RATE CONT	R901 (cw)	SAMPLING RATE Cont.	
653	wh-vt-gn-br	SRO INHIBIT	AT866	And Gate 1	
654	wh-vt	-6-V BIAS	AT509	(Power Supply)	
655	wh-vt-bu-bk	MAN RANGE	S903, 2	+15-V Bias	607

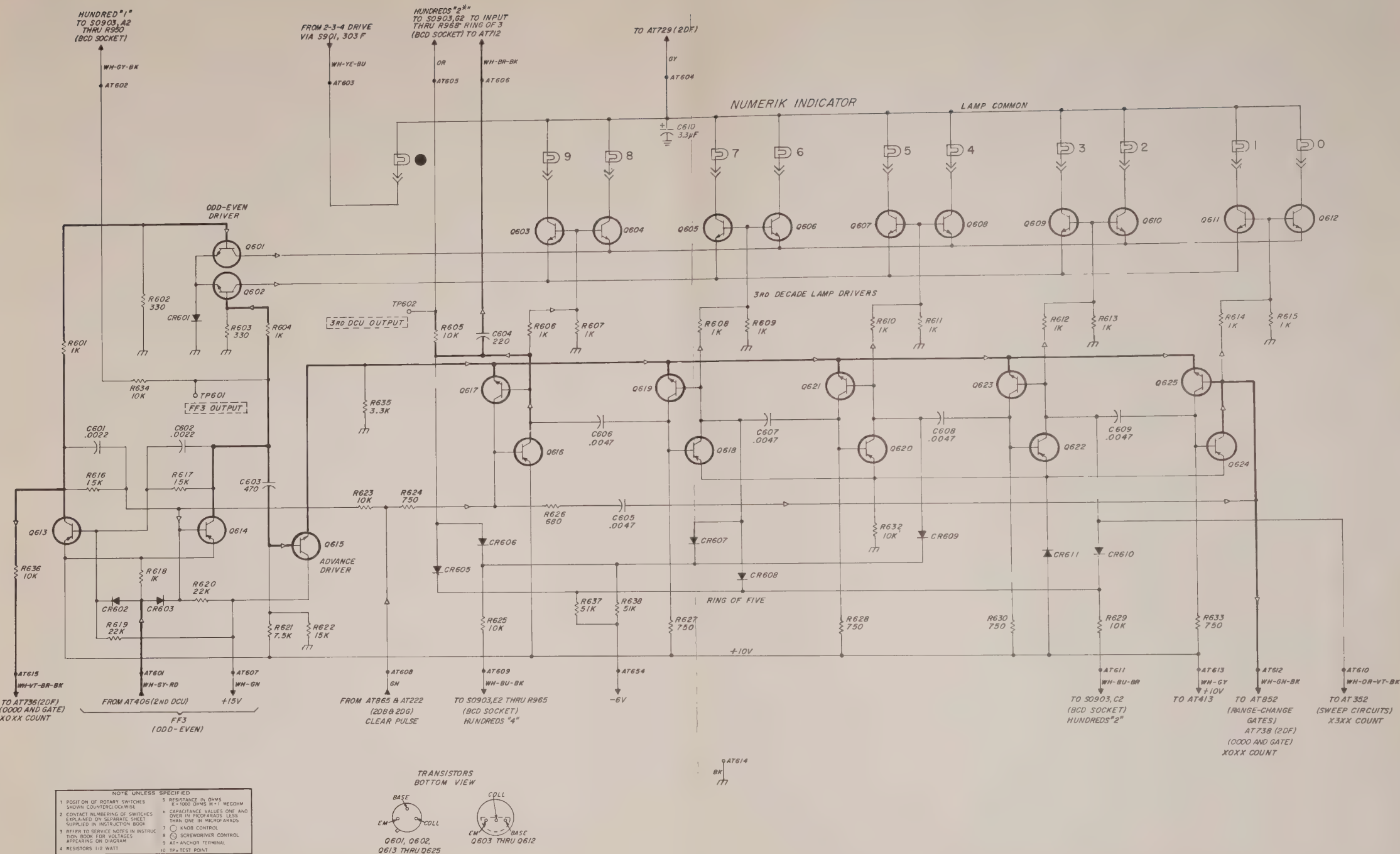


Figure 6-7b. Third-DCU-and-Sampling-Control Schematic Diagram.

ELECTRICAL PARTS LIST

Ref. No.	Description	Part No.	Fed. Mfg. Code	Mfg. Part No.	Fed. Stock No.
CAPACITORS					
C701 thru C703	Ceramic, 470 pF ±10% 500 V	4404-1478	72982	831, 470 pF ±10%	
C704	Ceramic, 0.01 µF +80-20% 500 V	4406-3109	72982	811, 0.01 µF ±10%	5910-977-7579
C705	Ceramic, 0.0047 µF ±10% 500 V	4407-2478	72982	841, 0.0047 µF ±10%	5910-931-0529
C706	Ceramic, 0.0047 µF ±10% 500 V	4407-2478	72982	841, 0.0047 µF ±10%	5910-931-0529
C707	Electrolytic, 3.3 µF ±20% 15 V	4450-4600	56289	150D335X0015A2	5910-837-9325
DIODES					
CR701	Type 1N4009	6082-1012	24446	1N4009	
CR702	Type 1N4009	6082-1012	24446	1N4009	
CR703	Type 1N645	6082-1016	24446	1N645	5961-944-8222
CR704	Type 1N3253	6081-1001	79089	1N3253	5961-814-4251
CR705	Type 1N3253	6082-1001	24446	1N3604	5960-995-2199
CR706	Type 1N3253	6082-1001	24446	1N3604	5960-995-2199
CR707	Type 1N3253	6082-1001	24446	1N3604	5960-995-2199
RESISTORS					
R701	Composition, 62 kΩ ±5% 1/2 W	6100-3625	01121	RC20GF623J	5905-249-3656
R702	Composition, 10 kΩ ±5% 1/2 W	6100-3105	01121	RC20GF103J	5905-185-8510
R703	Composition, 330 Ω ±5% 1/2 W	6100-1335	01121	RC20GF331J	5905-192-3971
R704	Composition, 1 kΩ ±5% 1/2 W	6100-2105	01121	RC20GF102J	5905-195-6806
R705	Composition, 10 kΩ ±5% 1/2 W	6100-3105	01121	RC20GF103J	5905-185-8510
R706	Composition, 10 kΩ ±5% 1/2 W	6100-3105	01121	RC20GF103J	5905-185-8510
R707	Composition, 3.3 kΩ ±5% 1/2 W	6100-2335	01121	RC20GF332J	5905-279-3506
R708	Composition, 1 kΩ ±5% 1/2 W	6100-2105	01121	RC20GF102J	5905-195-6806
R709	Composition, 3.3 kΩ ±5% 1/2 W	6100-2335	01121	RC20GF332J	5905-279-3506
R710	Composition, 1 kΩ ±5% 1/2 W	6100-2105	01121	RC20GF102J	5905-195-6806
R711	Composition, 62 kΩ ±5% 1/2 W	6100-3625	01121	RC20GF623J	5905-249-3656
R712	Composition, 3.3 kΩ ±5% 1/2 W	6100-2335	01121	RC20GF332J	5905-279-3506
R713	Composition, 7.5 kΩ ±5% 1/2 W	6100-2755	01121	RC20GF752J	5905-249-4195
R714	Composition, 1 kΩ ±5% 1/2 W	6100-2105	01121	RC20GF102J	5905-195-6806
R715	Composition, 10 kΩ ±5% 1/2 W	6100-3105	01121	RC20GF103J	5905-185-8510
R716	Composition, 10 kΩ ±5% 1/2 W	6100-3105	01121	RC20GF103J	5905-185-8510
R717	Composition, 1 kΩ ±5% 1/2 W	6100-2105	01121	RC20GF102J	5905-195-6806
R718	Composition, 15 kΩ ±5% 1/2 W	6100-3155	01121	RC20GF153J	5905-279-2616
R719	Composition, 750 Ω ±5% 1/2 W	6100-1755	01121	RC20GF751J	5905-195-9481
R720	Composition, 1 kΩ ±5% 1/2 W	6100-2105	01121	RC20GF102J	5905-195-6806
R721	Composition, 3.3 kΩ ±5% 1/2 W	6100-2335	01121	RC20GF332J	5905-279-3506
R722	Composition, 750 Ω ±5% 1/2 W	6100-1755	01121	RC20GF751J	5905-195-9481
R723	Composition, 1 kΩ ±5% 1/2 W	6100-2105	01121	RC20GF102J	5905-195-6806
R724	Composition, 750 Ω ±5% 1/2 W	6100-1755	01121	RC20GF751J	5905-195-9481
R725	Composition, 1 kΩ ±5% 1/2 W	6100-2105	01121	RC20GF102J	5905-195-6806
R726	Composition, 1 kΩ ±5% 1/2 W	6100-2105	01121	RC20GF102J	5905-195-6806
R727	Composition, 10 kΩ ±5% 1/2 W	6100-3105	01121	RC20GF103J	5905-185-8510
R728	Composition, 3 kΩ ±5% 1/2 W	6100-2305	01121	RC20GF302J	5905-279-1751
R729	Composition, 1.8 MΩ ±5% 1/2 W	6100-5185	01121	RC20GF185J	5905-279-1873
R730	Composition, 560 kΩ ±5% 1/2 W	6100-4565	01121	RC20GF564J	5905-279-2514
R731	Composition, 1 kΩ ±5% 1/2 W	6100-2105	01121	RC20GF102J	5905-195-6806
R732	Composition, 15 kΩ ±5% 1/2 W	6100-3155	01121	RC20GF153J	5905-279-2616
R733 thru R736	Composition, 470 Ω ±5% 1/2 W	6100-1475	01121	RC20GF471J	5905-192-3973
R737	Composition, 1 kΩ ±5% 1/2 W	6100-2105	01121	RC20GF102J	5905-195-6806
R738	Composition, 10 kΩ ±5% 1/2 W	6100-3105	01121	RC20GF103J	5905-185-8510
R739	Composition, 3.3 kΩ ±5% 1/2 W	6100-2335	01121	RC20GF332J	5905-279-3506
R740	Composition, 10 kΩ ±5% 1/2 W	6100-3105	01121	RC20GF103J	5905-185-8510
R741	Composition, 10 kΩ ±5% 1/2 W	6100-3105	01121	RC20GF103J	5905-185-8510
R742	Composition, 470 Ω ±5% 1/2 W	6100-1475	01121	RC20GF471J	5905-192-3973
R743	Composition, 1 kΩ ±5% 1/2 W	6100-2105	01121	RC20GF102J	5905-195-6806
R744	Composition, 470 Ω ±5% 1/2 W	6100-1475	01121	RC20GF471J	5905-192-3973
R745	Composition, 1 kΩ ±5% 1/2 W	6100-2105	01121	RC20GF102J	5905-195-6806
R746	Composition, 470 Ω ±5% 1/2 W	6100-1475	01121	RC20GF471J	5905-192-3973
R747	Composition, 1 kΩ ±5% 1/2 W	6100-2105	01121	RC20GF102J	5905-195-6806
R748	Composition, 470 Ω ±5% 1/2 W	6100-1475	01121	RC20GF471J	5905-192-3973
R749	Composition, 1 kΩ ±5% 1/2 W	6100-2105	01121	RC20GF102J	5905-195-6806
R750	Composition, 10 kΩ ±5% 1/2 W	6100-3105	01121	RC20GF103J	5905-185-8510
R751	Composition, 3.3 kΩ ±5% 1/2 W	6100-2335	01121	RC20GF332J	5905-279-3506
R752	Composition, 10 kΩ ±5% 1/2 W	6100-3105	01121	RC20GF103J	5905-185-8510
R753	Composition, 10 kΩ ±5% 1/2 W	6100-3105	01121	RC20GF103J	5905-185-8510
R754	Composition, 3.3 kΩ ±5% 1/2 W	6100-2335	01121	RC20GF332J	5905-279-3506

ELECTRICAL PARTS LIST (cont)

Ref. No.	Description	Part No.	Fed. Mfg. Code	Mfg. Part No.	Fed. Stock No.
RESISTORS (Cont)					
R755 thru R758	Composition, 10 kΩ ±5% 1/2 W	6100-3105	01121	RC20GF103J	5905-185-8510
R759	Composition, 3.3 kΩ ±5% 1/2 W	6100-2335	01121	RC20GF332J	5905-279-3506
R760	Composition, 10 kΩ ±5% 1/2 W	6100-3105	01121	RC20GF103J	5905-185-8510
R761	Composition, 2.2 kΩ ±5% 1/2 W	6100-2225	01121	RC20GF222J	5905-279-1876
TRANSISTORS					
Q701	Type 2N1302	8210-1018	96214	2N1302	5960-086-0039
Q702	Type 2N1305	8210-1305	96214	2N1305	5961-853-1079
Q703	Type 2N1305	8210-1305	96214	2N1305	5961-853-1079
Q704	Type 2N1302	8210-1018	96214	2N1302	5960-086-0039
Q705	Type 2N1302	8210-1018	96214	2N1302	5960-086-0039
Q706	Type 2N1303	8210-1019	96214	2N1303	
Q707	Type 2N1302	8210-1018	96214	2N1302	5960-086-0039
Q708	Type 2N1303	8210-1019	96214	2N1303	
Q709	Type 2N1302	8210-1018	96214	2N1302	5960-086-0039
Q710	Type 2N1303	8210-1019	96214	2N1303	
Q711	Type 2N3250	8210-1089	80211	2N3250	
Q712	Type 2N1304	8210-1304	01295	2N1304	5961-892-0800
Q713	Type 2N1305	8210-1305	96214	2N1305	5961-853-1079
Q714	Type 2N1302	8210-1018	96214	2N1302	5960-086-0039
Q715	Type 2N3390	8210-1077	24446	2N3390	
Q716 thru Q719	Type 2N1302	8210-1018	96214	2N1302	5960-086-0039
Q720 thru Q722	Type 2N3414	8210-1047	24446	2N3414	5961-989-2749
Q723 thru Q731	Type 2N3416	8210-1047	24446	2N3416	5961-989-2749

TABLE 6-6

Relay-Drive, Polarity-Control, and MSD Etched-Board Assembly
(P/N 1820-2771)
Connections

Anchor Terminal	Wire Color	Signal	Immediate Connection	Destination (Origin)	Anchor Terminal
701	wh-or-gn-bk	+ POL OUT	AT890	±Bulb	
702	wh-gy-rd-br	+ POL OUT (ENABLE + COMP)	AT226	+ Comparator	
703	wh-vt-bu	+ POL OUT	R957, SO903, B5	DATA OUTPUT	
704	wh-or-vt-br	- POL OUT (ENABLE - COMP)	AT216	- Comparator	
705	wh-ye-bk	GND (For LOG)	S901, 202F	Chassis Gnd**	S901 (P-I)
	wh-ye-bk	GND (For AC, kΩ, MΩ)	SO902, 27	Plug-In MEASUREMENT Switch	
706	wh-bk	WRONG POL (INHIB)	S901, 401F	Range Gates	
			AT853		
707	wh-vt-rd	THOUS "1"	R955, SO903, B1	DATA OUTPUT	
708	wh-vt-gn	1XXX	AT850	Range Gates	
709	wh-vt-gy	THOUS "2"	R963, SO903, D1	DATA OUTPUT	
710	wh-gy	+10-V BIAS	AT413	(2ND DCU Bias)	
711	wh-gy-bk	2XXX	AT861	Range Gates	
712	wh-br-bk	3RD DCU OUTPUT	AT606	(3RD DCU)	
713	gn	CLEAR PULSE	AT608	(Clear Driver)	
714	wh-or-br	0XXX	AT851	Range Gates	
715	wh-gn	+15-V BIAS	AT504	(Power Supply)	
716	wh-rd-bu-bk	"0, 1, 2" DRIVE OUT	S901, 210F	"LOG" 0, 1, 2 or X.XXX Dec Point	717 or 730**
				Ground via CR704	734**
717	wh-rd-br-bk	DRIVER "GND"	S901, 207F	Range-Change Ring of 3	
718	wh-or-bu	"0, 1, 2" DRIVE	AT802	"A" Relay	103*
719	wh-ye-gn	"A" RELAY DRIVE	SO902, 19	"LOG" 2, 3, 4 or XX.XX Dec Point	725 or 803**
720	wh-rd-bu-br	"2, 3, 4" DRIVE OUT	S901, 301F	Range-Change Ring of 3	
721	wh-or-gn	"2, 3, 4" DRIVE	AT803	V-mV FF	
722	wh-or-rd	"4, 5, 6" DRIVE	AT805	(Signal not used.)	
723	wh-or-gy	mV SIG	AT807	"2, 3, 4" Driver	720**
724	wh-or-vt	V SIG	AT808	"LOG" 4, 5, 6 or XXX.X Dec Point	727 or 403**
			SO902, 24	"4, 5, 6" Driver	726**
725	wh-rd-gn-bk	"2, 3, 4" DRIVE OUT	S901, 302F	mV Bulb	
726	wh-rd-gn-br	"4, 5, 6" DRIVE	S901, 304F	(Power Supply)	504
				"0, 1, 2" Driver	716**
727	wh-rd-gn-bu	"4, 5, 6" DRIVE	S901, 305F	"D" Relay (P-I)	
728	wh-gy-br-bk	mV DRIVE	S901, 307F	Lower Stop	863*
729	gy	LAMP COMMON +15 V	AT304, 404, 604	and P-I MEAS Sw.	
730	wh-ye-br	"0, 1, 2" DRIVE OUT	S901, 212F	"B" Relay (LOG) SO902, 28	106
731	wh-bu-br-bk	"D" RELAY DRIVE	SO902, 20	db Bulb (LIN) and	899*
732	wh-gy-bu-bk	"V" DRIVE OUT	SO902, 30	P-I MEAS Sw.	
			S901, 310F	"B" Relay	106*
				"0, 1, 2" Bulbs (LOG)	717**
733	wh-gn-bu-bk	"B" RELAY DRIVE	SO902, 21	(2ND DCU)	
734	wh-gn-bu-br	DRIVER "GND"	S901, 207F	(3RD DCU)	
735	bk	GND		(1ST DCU)	
736	wh-vt-br-bk	XX0X AND X0XX	AT412	(3RD DCU)	
			AT615	Range Gates	
737	wh-gy-bu	XXX0	AT312	Polarity FF	
738	wh-gn-bk	X0XX	AT612		
			AT852		
739	wh-ye	WRONG POL RESET	AT220		

* Connections to these points are made via the Plug-In Refer to the Plug-In socket diagram for intermediate connections.
** These connections are made via the associated switch. Refer to the diagram containing the anchor terminals involved for intermediate connections.

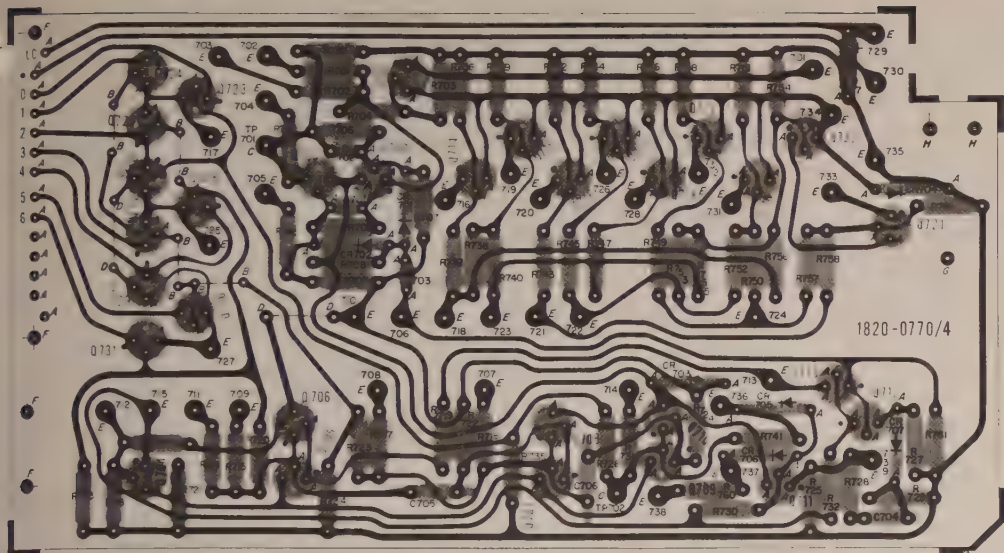


Figure 6-8a. Relay-Drive, Polarity-Control, and MSD Etched-Board Assembly (P/N 1820-2771).

NOTE: The number appearing on the foil side is not the part number. The dot on the foil at the transistor socket indicates the collector lead.

Rotary switch sections are shown as viewed from the panel end of the shaft. The first digit of the contact number refers to the section. The section nearest the panel is 1, the next section back is 2, etc. The next two digits refer to the contact. Contact 01 is the first position clockwise from a strut screw (usually the screw above the locating key), and the other contacts are numbered sequentially (02, 03, 04, etc.), proceeding clockwise around the section. A suffix F or R indicates that the contact is on the front or rear of the section, respectively.

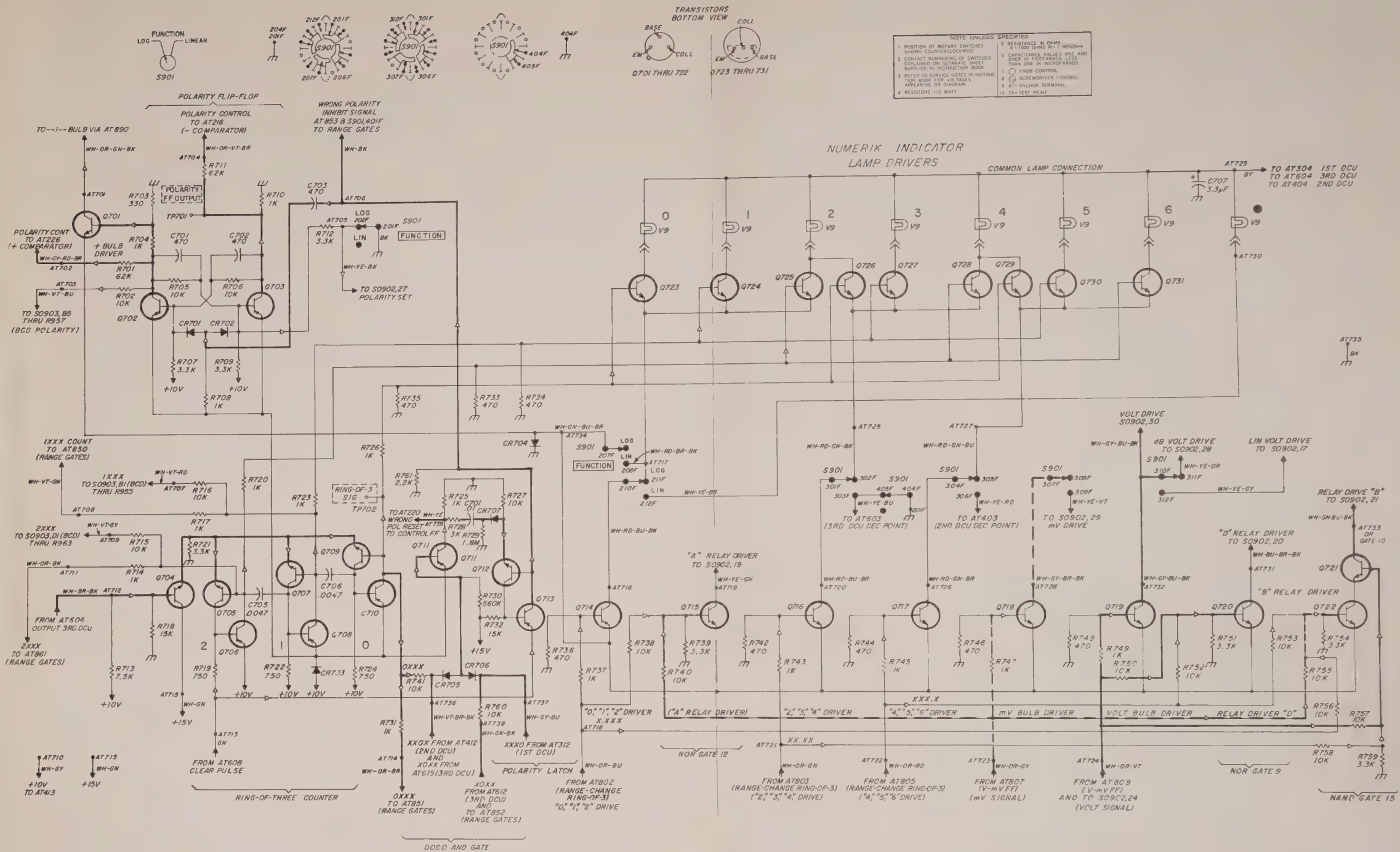


Figure 6-8b. Relay-Drive, Polarity-Control and MSD Schematic Diagram.

ELECTRICAL PARTS LIST

Ref. No.	Description	Part No.	Fed. Mfg. Code	Mfg. Part No.	Fed. Stock No.
CAPACITORS					
C801	Ceramic, 470 pF ±10% 500 V	4404-1478	72982	831, 470 pF ±10%	
C802 thru C807	Ceramic, 0.0047 µF ±10% 500 V	4407-2478	72982	841, 0.0047 µF ±10%	5910-931-0529
C808 thru C809	Ceramic, 470 pF ±10% 500 V	4404-1478	72982	831, 470 pF ±10%	
C811 thru C812	Ceramic, 470 pF ±10% 500 V	4404-1478	72982	831, 470 pF ±10%	
C812	Ceramic, 1 µF ±20% 25 V	4400-2070	80183	5C13, 1 µF ±20%	
C850	Ceramic, 470 pF ±10% 500 V	4404-1478	72982	831, 470 pF ±10%	
C851	Plastic, 0.22 µF ±10% 100 V	4860-7981			
C852	Ceramic, 470 pF ±10% 500 V	4404-1478	72982	831, 470 pF ±10%	
C853	Electrolytic, 3.3 µF ±20% 15 V	4450-4600	56289	150D335X0015A2	5910-837-9325
C854	Ceramic, 820 pF ±10% 500 V	4405-1828	72982	801, 820 pF ±10%	
C855	Ceramic, 820 pF ±10% 500 V	4405-1828	72982	801, 820 pF ±10%	
C860	Ceramic, 820 pF ±10% 500 V	4405-1828	72982	801, 820 pF ±10%	
C861	Ceramic, 0.001 µF +80-20% 500 V	4404-2109	72982	831, 0.001 µF +80-20%	5910-983-9994
DIODES					
CR801	Type 1N645	6082-1016	24446	1N645	5961-944-8222
CR802	Type 1N645	6082-1016	24446	1N645	5961-944-8222
CR803	Type 1N4009	6082-1012	24446	1N4009	
CR804	Type 1N4009	6082-1012	24446	1N4009	
CR805	Type 1N645	6082-1016	24446	1N645	5961-944-8222
CR806 thru CR809	Type 1N4009	6082-1012	24446	1N4009	
CR810 thru CR811	Type 1N4009X	6082-1016	24446	1N645	5961-944-8222
CR811 thru CR864	Type 1N4009	6082-1012	24446	1N4009	
CR866	Type 1N4009	6082-1012	24446	1N4009	
CR867	Type 1N4009	6082-1012	24441	1N4009	
RESISTORS					
R801	Composition, 7.5 kΩ ±5% 1/2 W	6100-2755	01121	RC20GF752J	5905-249-4195
R802	Composition, 15 kΩ ±5% 1/2 W	6100-3155	01121	RC20GF153J	5905-279-2616
R803	Composition, 3.3 kΩ ±5% 1/2 W	6100-2335	01121	RC20GF332J	5905-279-3506
R804	Composition, 750 Ω ±5% 1/2 W	6100-1755	01121	RC20GF751J	5905-195-9481
R805	Composition, 100 kΩ ±5% 1/2 W	6100-4105	01121	RC20GF104J	5905-195-6761
R806	Composition, 100 kΩ ±5% 1/2 W	6100-4105	01121	RC20GF104J	5905-195-6761
R807	Composition, 10 kΩ ±5% 1/2 W	6100-3105	01121	RC20GF103J	5905-185-8510
R808	Composition, 750 Ω ±5% 1/2 W	6100-1755	01121	RC20GF751J	5905-195-9481
R809	Composition, 100 kΩ ±5% 1/2 W	6100-4105	01121	RC20GF104J	5905-195-6761
R810	Composition, 100 kΩ ±5% 1/2 W	6100-4105	01121	RC20GF104J	5905-195-6761
R812	Composition, 750 Ω ±5% 1/2 W	6100-1755	01121	RC20GF751J	5905-195-9481
R813	Composition, 10 kΩ ±5% 1/2 W	6100-3105	01121	RC20GF103J	5905-185-8510
R814 thru R817	Composition, 100 kΩ ±5% 1/2 W	6100-4105	01121	RC20GF104J	5905-195-6761
R818	Composition, 1 kΩ ±5% 1/2 W	6100-2105	01121	RC20GF102J	5905-195-6806
R819	Composition, 5.1 kΩ ±5% 1/2 W	6100-2515	01121	RC20GF512J	5905-279-2019
R820	Composition, 5.1 kΩ ±5% 1/2 W	6100-2515	01121	RC20GF512J	5905-279-2019
R821	Composition, 3.3 kΩ ±5% 1/2 W	6100-2335	01121	RC20GF332J	5905-279-3506
R822	Composition, 22 kΩ ±5% 1/2 W	6100-3225	01121	RC20GF223J	5905-171-2004
R823	Composition, 1 kΩ ±5% 1/2 W	6100-2105	01121	RC20GF102J	5905-195-6806
R824	Composition, 22 kΩ ±5% 1/2 W	6100-3225	01121	RC20GF223J	5905-171-2004
R825	Composition, 10 kΩ ±5% 1/2 W	6100-3105	01121	RC20GF103J	5905-185-8510
R826	Composition, 10 kΩ ±5% 1/2 W	6100-3105	01121	RC20GF103J	5905-185-8510
R827	Composition, 3.3 kΩ ±5% 1/2 W	6100-2335	01121	RC20GF332J	5905-279-3506
R828	Composition, 10 kΩ ±5% 1/2 W	6100-3105	01121	RC20GF103J	5905-185-8510
R850	Composition, 22 kΩ ±5% 1/2 W	6100-3225	01121	RC20GF223J	5905-171-2004
R851 thru R856	Composition, 10 kΩ ±5% 1/2 W	6100-3105	01121	RC20GF103J	5905-185-8510
R857	Composition, 22 kΩ ±5% 1/2 W	6100-3225	01121	RC20GF223J	5905-171-2004
R858	Composition, 10 kΩ ±5% 1/2 W	6100-3105	01121	RC20GF103J	5905-185-8510
R859	Composition, 10 kΩ ±5% 1/2 W	6100-3105	01121	RC20GF103J	5905-185-8510
R860	Composition, 22 kΩ ±5% 1/2 W	6100-3225	01121	RC20GF223J	5905-171-2004
R861	Composition, 10 kΩ ±5% 1/2 W	6100-3105	01121	RC20GF103J	5905-185-8510
R862	Composition, 2.2 kΩ ±5% 1/2 W	6100-2225	01121	RC20GF222J	5905-279-1876

ELECTRICAL PARTS LIST (cont)

Ref. No.	Description	Part No.	Fed. Mfg. Code	Mfg. Part No.	Fed. Stock No.
RESISTORS (Cont)					
R863	Composition, 10 kΩ ±5% 1/2 W	6100-3105	01121	RC20GF103J	5905-185-8510
R864	Composition, 10 kΩ ±5% 1/2 W	6100-3105	01121	RC20GF103J	5905-185-8510
R865	Composition, 22 kΩ ±5% 1/2 W	6100-3225	01121	RC20GF223J	5905-171-2004
R866	Composition, 10 kΩ ±5% 1/2 W	6100-3105	01121	RC20GF103J	5905-185-8510
R867	Composition, 4.7 kΩ ±5% 1/2 W	6100-2475	01121	RC20GF472J	5905-279-3504
R868	Composition, 1.8 kΩ ±5% 1/2 W	6100-2185	01121	RC20GF182J	5905-190-8881
R869	Composition, 2.2 kΩ ±5% 1/2 W	6100-2225	01121	RC20GF222J	5905-279-1876
R870	Composition, 1 kΩ ±5% 1/2 W	6100-2105	01121	RC20GF102J	5905-195-6806
R871	Composition, 100 kΩ ±5% 1/2 W	6100-4105	01121	RC20GF104J	5905-195-6761
R872	Composition, 10 kΩ ±5% 1/2 W	6100-3105	01121	RC20GF103J	5905-185-8510
R873	Composition, 1 kΩ ±5% 1/2 W	6100-2105	01121	RC20GF102J	5905-195-6806
R874	Composition, 10 kΩ ±5% 1/2 W	6100-3105	01121	RC20GF013J	5905-185-8510
R875	Composition, 27 kΩ ±5% 1/2 W	6100-3275	01121	RC20GF272J	5905-279-3499
R876	Composition, 100 kΩ ±5% 1/2 W	6100-4105	01121	RC20GF104J	5905-185-8510
R877	Composition, 4.7 kΩ ±5% 1/2 W	6100-2475	01121	RC20GF472J	5905-279-3504
R878	Composition, 100 kΩ ±5% 1/2 W	6100-4105	01121	RC20GF104J	5905-195-6761
R879	Composition, 1 MΩ ±5% 1/2 W	6100-5105	01121	RC20GF105J	5905-192-0390
R880	Composition, 100 kΩ ±5% 1/2 W	6100-4105	01121	RC20GF104J	5905-195-6761
R881	Composition, 20 kΩ ±5% 1/2 W	6100-3205	01121	RC20GF203J	5905-192-0649
R882	Composition, 100 kΩ ±5% 1/2 W	6100-4105	01121	RC20GF104J	5905-195-6761
R883	Composition, 10 kΩ ±5% 1/2 W	6100-3105	01121	RC20GF103J	5905-185-8510
R884	Composition, 470 Ω ±5% 1/2 W	6100-1475	01121	RC20GF471J	5905-192-3973
R885	Composition, 560 kΩ ±5% 1/2 W	6100-4565	01121	RC20GF564J	5905-279-2514
R887	Composition, 1 kΩ ±5% 1/2 W	6100-2105	01121	RC20GF102J	5905-195-6806
R888	Composition, 15 kΩ ±5% 1/2 W	6100-3155	01121	RC20GF153J	5905-279-2616
R889	Composition, 15 kΩ ±5% 1/2 W	6100-3155	01121	RC20GF153J	5905-279-2616
R890	Composition, 1 kΩ ±5% 1/2 W	6100-2105	01121	RC20GF102J	5905-195-6806
R891	Composition, 47 kΩ ±5% 1/2 W	6100-3475	01121	RC20GF473J	5905-254-9201
R893	Composition, 1 kΩ ±5% 1/2 W	6100-2105	01121	RC20GF102J	5905-195-6806
R894	Composition, 4.7 Ω ±5% 1/2 W	6100-9475	01121	EB, 4.7 Ω ±5%	
R895	Composition, 150 kΩ ±5% 1/2 W	6100-4155	01121	RC20GF154J	5905-279-2522
R896	Composition, 1 kΩ ±5% 1/2 W	6100-2105	01121	RC20GF102J	5905-195-6806
TRANSISTORS					
Q801	Type 2N1302	8210-1018	96214	2N1302	5960-086-0039
Q802	Type 2N1302	8210-1018	96214	2N1302	5960-086-0039
Q803	Type 2N1303	8210-1019	96214	2N1302	
Q804	Type 2N1302	8210-1018	96214	2N1302	5960-086-0039
Q805	Type 2N1303	8210-1019	96214	2N1303	
Q806	Type 2N1302	8210-1018	96214	2N1302	5960-086-0039
Q807	Type 2N1303	8210-1019	96214	2N1303	
Q808	Type 2N1305	8210-1305	96214	2N1305	5961-853-1079
Q809	Type 2N1305	8210-1305	96214	2N1305	5961-853-1079
Q810	Type 2N1302	8210-1018	96214	2N1302	5960-086-0039
Q811	Type 2N1302	8210-1018	96214	2N1302	5960-086-0039
Q850 thru Q853	Type 2N1302	8210-1019	96214	2N1302	5960-086-0039
Q854 thru Q856	Type 2N1304	8210-1304	01295	2N1304	5961-892-0800
Q857	Type 2N1305	8210-1305	96214	2N1305	5961-853-1079
Q858	Type 2N1305	8210-1305	96214	2N1305	5961-853-1079
Q859	Type 2N3414	8210-1047	24446	2N3414	5961-989-2749
Q860	Type 2N3414	8210-1047	24446	2N3414	5961-989-2749

TABLE 6-7 Range-Control Etched-Board Assembly (P/N 1820-2781) Connections					
Anchor Terminal	Wire Color	Signal	Immediate Connection	Destination (Origin)	Anchor Terminal
802	wh-or-bu	"0, 1, 2"	AT718 SO902, 2	"0, 1, 2" Driver SO902, 18 via R904	*
803	wh-or-gn	"2, 3, 4" DRIVE	AT721	"2, 3, 4" Driver	
804	wh-vt-rd-bu	"2, 3, 4" DRIVE	R952, SO903, A6	DATA OUTPUT	
805	wh-or-rd	"4, 5, 6" DRIVE	AT722	"4, 5, 6" Driver	
806	wh-vt-rd-br	"4, 5, 6" DRIVE	R961, SO903, C6	DATA OUTPUT	
807	wh-or-gy	mV DRIVE	AT723	mV Driver	
808	wh-or-vt	V DRIVE	AT724	V Driver	
809	wh-vt-rd-bk	V	R958, SO903, B7	DATA OUTPUT	
810	wh-gy	+10-V BIAS	AT413	(2ND DCU Bias)	
815	wh-gn	+15-V BIAS	AT504	(Power Supply)	
850	wh-vt-gn	1XXX	AT708	(MSD Ring of 3)	
851	wh-or-br	0XXX	AT714	(0000 And Gate)	
852	wh-gn-bk	X0XX OR X1XX	AT612	(3RD DCU)	
853	wh-bk	WRONG POL, INHIBIT	AT706	(Polarity Latch)	
854	wh-gy-bu-br	RANGE INC	S903, 6 SO902, 3	(-6-V BIAS INC) AC mV Bulb	862** 885**
855	wh-gy-gn-bu	WRONG POL, INHIBIT	S901, 402F	(Polarity FF)	
856	wh-or-vt-rd	MAN (+15 V)	S902, 4	(+15-V Bias)	706**
857	wh-gy-gn-bk	RANGE DEC	S903, 4	(-6-V Bias (DEC))	815**
861	wh-or-bk	2XXX	AT711	(MSD Ring of 3)	
862	wh-vt	-6-V BIAS	AT509	(Power Supply)	
863	wh-vt-bu-br	LOWER STOP	SO902, 26	(V Driver) and P-I MEAS Sw.	Sw.
864	bu	COUNT SIG	AT351	(Control FF)	732*
865	gn	CLEAR PULSE	AT222, 308, 408, 608, 713	(Clear Driver)	
866	wh-vt-gn-br	SRO INHIBIT	AT653	SRO	
867	br	PRINT COMMAND	R954, SO903, A12	DATA OUTPUT	
868	bk	GND			
880	wh-vt-rd-gn	V DRIVE OUT	SO902, 5	P-I MEAS Sw.	*
881	wh-vt-gy-bk	AC SIG	SO902, 8	P-I MEAS Sw.	*
882	wh-vt-gy-br	kΩ SIG	SO902, 11	P-I MEAS Sw.	*
883	wh-vt-gy-bu	MΩ SIG	SO902, 10	P-I MEAS Sw.	*
884	wh-vt-gy-gn	mV SIG	SO902, 6	P-I MEAS Sw.	*
885	wh-vt-gy-rd	AC mV	SO902, 12	P-I MEAS Sw.	*
886	wh-or-br-bk	Ω SIG	SO902, 9	P-I MEAS Sw.	*
887	wh-or-bu-bk	µA SIG	SO902, 14	P-I MEAS Sw.	*
888	wh-or-bu-br	nA SIG	SO902, 13	P-I MEAS Sw.	*
889	wh-or-gn-br	db SIG	SO902, 25 R953, SO903, A8	SO902, 17 via CR901 DATA OUTPUT	*
890	wh-or-gn-bk	±SIG	S901, 205F	Ground (LOG)	**
891	wh-or-vt-bu	+60 SIG	AT701	Polarity FF	
892	wh-gy-rd-bu	WRONG POL, INHIBIT	SO902, 7		
893	wh-gy-rd-bk	AUTO (0 V)	S901, 403F S902, 1	(Polarity FF) Ground (AUTO)	853** **

* Connections to these points are made via the Plug-In. Refer to the Plug-In socket diagram for intermediate connections.
** These connections are made via the associated switch. Refer to the diagram containing the anchor terminals involved for intermediate connections.

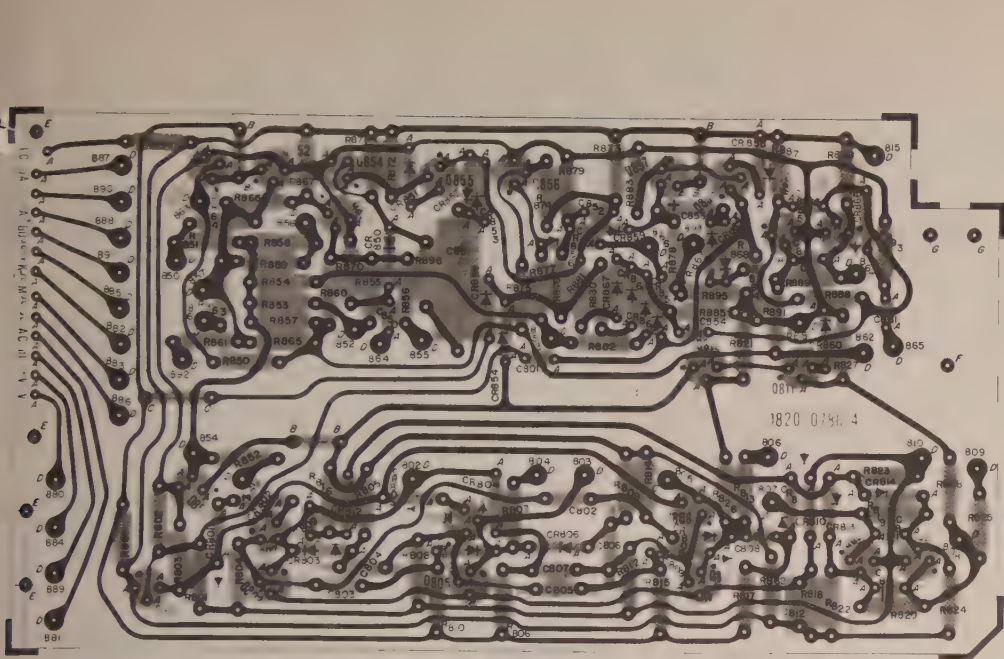


Figure 6-9a. Range-Control Etched-Board Assembly (P/N 1820-2781).

NOTE: The number appearing on the foil side is not the part number. The dot on the foil at the transistor socket indicates the collector lead.

Rotary switch sections are shown as viewed from the panel end of the shaft. The first digit of the contact number refers to the section. The section nearest the panel is 1, the next section back is 2, etc. The next two digits refer to the contact. Contact 01 is the first position clockwise from a strut screw (usually the screw above the locating key), and the other contacts are numbered sequentially (02, 03, 04, etc), proceeding clockwise around the section. A suffix F or R indicates that the contact is on the front or rear of the section, respectively.

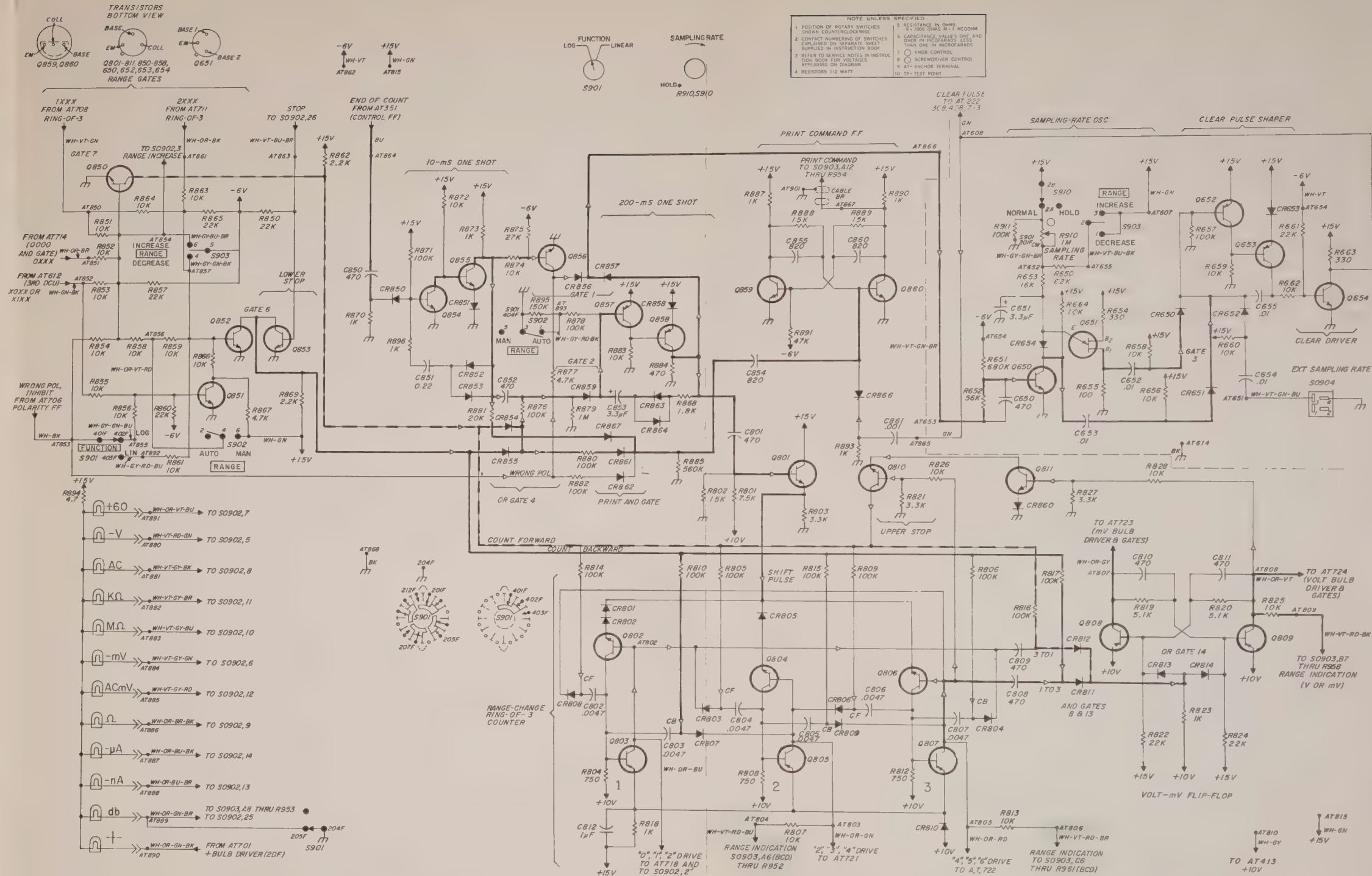


Figure 6-9b. Range-Control Schematic Diagram.

ELECTRICAL PARTS LIST

Ref. No.	Description	Part No.	Fed. Mfg. Code	Mfg. Part No.	Fed. Stock No.
CAPACITORS					
C502	Ceramic, 0.047 μ F +80-20% 500 V	4409-3479	72982	3851, 0.047 μ F +80-20%	
C503A	Electrolytic, 75 μ F 150 V	4450-5619	80183	150D, 75 μ F, 150 V	
C503B					
C504	Ceramic, 0.01 μ F +80-20% 500 V	4406-3109	72982	811, 000X5U103X	5910-754-7049
C505A	Electrolytic, 75 μ F 150 V	4450-5619	80183	150D, 75 μ F, 150 V	5910-983-9994
C505B					
C506	Ceramic, 0.001 μ F +80-20% 500 V	4404-2109	72982	831, 0.001 μ F +80-20%	5910-983-9994
C507A	Electrolytic, 750 μ F 25 V	4450-0700	90201	203828S10C10X2	5910-976-9415
C507B					
C507C	Electrolytic, 750 μ F 25 V	4450-0700	90201	203828S10C10X2	5910-976-9415
C508A					
C508B	Electrolytic, 750 μ F 25 V	4450-0700	90201	203828S10C10X2	5910-976-9415
C508C					
C509A	Electrolytic, 750 μ F 25 V	4450-0700	90201	203828S10C10X2	5910-976-9415
C509B					
C509C	Electrolytic, 68 μ F $\pm$ 20% 15 V	4450-5615	80183	150D68X0015R2	5910-931-0529
C510					
C511	Ceramic, 0.0047 μ F $\pm$ 10% 500 V	4407-2478	72982	841, 0.0047 μ F $\pm$ 10%	
C512A	Electrolytic, 750 μ F 25 V	4450-0700	90201	203828S10C10X2	5910-976-9415
C512B					
C512C	Electrolytic, 75 μ F 150 V	4450-5619	80183	150D, 75 μ F 15 V	
C513A					
C513B	Ceramic, 0.22 μ F +80-20% 12 V	4432-4229	56289	29C365, 0.22 μ F +80-20%	5910-952-8659
C514					
C515	Ceramic, 0.02 μ F +80-20% 50 V	4402-3200	01121	36-203W, 0.02 μ F +80-20%	
C516	Ceramic, 0.022 μ F +80-20% 500 V	4407-3229	72982	CC63, 0.022 μ F +80-20%	5910-842-2961
C517	Ceramic, 0.05 μ F +80-20% 50 V	4403-3500	01121	40-503W	5910-883-7321

DIODES

CR501	Type 1N3254	6081-1002	09213	1N3254	5961-082-3988
thru CR508					
CR509	Type 1N3253	6081-1001	79089	1N3253	5961-814-4251
thru CR516					
CR517	Type 1N3254	6081-1002	09213	1N3254	5961-082-3988
thru CR520					
CR521	Type 1N978A, $\pm$ 5% 51 V 0.4 W	6083-1052	80131	1N978B	5960-858-4212
CR522	Type 1N645	6082-1016	24446	1N645	5961-944-8222
CR523	Type 1N645	6082-1016	24446	1N645	5961-944-8222
CR524	Type 1N752, $\pm$ 10% 5.6 V 0.4 W	6083-1004	07910	1N752	
CR525	Type 1N978A, $\pm$ 5% 51 V 0.4 W	6083-1052	80131	1N978B	5960-858-4212
CR526	Type 1N2166A, $\pm$ 0.2% 9.4 V 0.4 W	6083-1011	07595	1N2166A	
CR527	Type 1N3256	6081-1004	12672	1N3256	5960-972-9395
thru CR529					

RESISTORS

R501	Composition, 680 Ω $\pm$ 5% 1/2 W	6100-1685	01121	RC20GF681J	5905-195-6791
R502	Composition, 100 k Ω $\pm$ 5% 1/2 W	6100-4105	01121	RC20GF104J	5905-195-6761
R503	Composition, 3.3 k Ω $\pm$ 5% 1 W	6110-2335	01121	RC32GF332J	5905-299-2059
R504	Power, 240 Ω $\pm$ 5% 5 W	6660-1245	80183	246E, 240 Ω $\pm$ 5%	
R505	Composition, 820 k Ω $\pm$ 5% 1/2 W	6100-4825	01121	RC20GF824J	5905-221-5848
R506	Composition, 1 k Ω $\pm$ 5% 1/2 W	6100-2105	01121	RC20GF102J	5905-195-6806
R507	Composition, 100 k Ω $\pm$ 5% 1/2 W	6100-4105	01121	RC20GF104J	5905-195-6761
R508	Precision, 20 k Ω $\pm$ 0.05% 77 W	6690-4335	24655	6690-4335	
R509	Potentiometer, wire wound $\pm$ 10% 100 Ω	6056-0132	11236	115, 100 Ω $\pm$ 10%	
R510	Precision, 20 k Ω $\pm$ 0.05% 77 W	6690-4335	24655	6690-4335	
R511	Composition, 33 Ω $\pm$ 5% 1/2 W	6100-0335	01121	RC20GF330J	5905-192-4490
R512	Composition, 360 Ω $\pm$ 5% 2 W	6120-1365	01121	RC42GF361J	5905-279-1915
R513	Film, 2.05 k Ω $\pm$ 1% 1/2 W	6450-1205	75042	CEC, 2.05 k Ω $\pm$ 1%	
R514	Film, 1 k Ω $\pm$ 1% 1/2 W	6450-1100	75042	CEC, 1 k Ω $\pm$ 1%	5905-552-5444
R517	Composition, 220 Ω $\pm$ 5% 1/2 W	6100-1225	01121	RC20GF221J	5905-279-3513
R518	Composition, 4.3 k Ω $\pm$ 5% 1/2 W	6100-2435	01121	RC20GF432J	5905-257-0935
R519	Composition, 1 k Ω $\pm$ 5% 1/2 W	6100-2105	01121	RC20GF102J	5905-195-6806
R520	Composition, 6.8 k Ω $\pm$ 5% 1/2 W	6100-2685	01121	RC20GF682J	5905-279-3503
R521	Composition, 200 Ω $\pm$ 5% 1/2 W	6100-1205	01121	RC20GF201J	5905-279-2674
R522	Composition, 10 Ω $\pm$ 5% 1/2 W	6100-0105	01121	RC20GF100J	5905-190-8883
R523	Power, 240 Ω $\pm$ 5% 5 W	6660-1245	80183	246E, 240 Ω $\pm$ 5%	
R524	Composition, 1.5 k Ω $\pm$ 10% 2 W	6120-2155	01121	RC42GF152J	5905-279-2530

ELECTRICAL PARTS LIST (cont)

Ref. No.	Description	Part No.	Fed. Mfg. Code	Mfg. Part No.	Fed. Stock No.
RESISTORS (Cont)					
R525	Composition, 1 k Ω $\pm$ 5% 1/2 W	6100-2105	01121	RC20GF102J	5905-195-6806
R526	Composition, 220 Ω $\pm$ 5% 1/2 W	6100-1225	01121	RC20GF221J	5905-279-3513
R527	Power, 9.06 k Ω $\pm$ 5% 3 W	6680-2906	80183	242E, 9.06 k Ω $\pm$ 5%	
R528	Composition, 100 k Ω $\pm$ 5% 1/2 W	6100-4105	01121	RC20GF104J	5905-195-6761
R529	Composition, 47 k Ω $\pm$ 5% 1/2 W	6100-3475	01121	RC20GF473J	5905-254-9201
R530	Precision, 1.80 k Ω $\pm$ 0.05% 77 W	6690-4333	24655	6690-4333	
R531	Potentiometer, wirewound 1 k Ω $\pm$ 10%	6056-0138	11236	115, 1 k Ω $\pm$ 10%	
R532	Precision, 16.883 k Ω $\pm$ 0.05% 77 W	6690-4334	24655	6690-4334	
R533	Composition, 200 Ω $\pm$ 5% 1/2 W	6100-1205	01121	RC20GF201J	5905-279-2674

TRANSISTORS

Q501	Type 2N3905	8210-1114	04713	2N3905	
Q502	Type 2N2147	8210-1072	75491	2N2147	
Q503	Type 2N3414	8210-1047	24446	2N3414	5961-989-2749
Q504	Type 2N3905	8210-1114	04713	2N3905	
Q505	Type 2N3414	8210-1047	24446	2N3414	5961-989-2749
Q506	Type 2N2192	8210-1085	24454	2N2192	
Q507	Type 2N3414	8210-1047	24446	2N3414	5961-989-2749
Q508	Type 2N3414	8210-1047	24446	2N3414	5961-989-2749
Q509	Type 2N698	8210-1058	93916	2N698	5960-985-3709
Q510	Type 2N3414	8210-1047	24446	2N3414	5961-989-2749
Q511	Type 2N3414	8210-1047	24446	2N3414	5961-989-2749
Q512	Type 2N3414	8210-1047	24446	2N3414	5961-989-2749

MISCELLANEOUS

J501	JACK	1820-2751			
J502	JACK	1820-2751			
J503	JACK	1820-2751			
PL501	PLUG	1820-0300			
PL502	PLUG	1820-0300			
PL503	PLUG	1820-0300			

TABLE 6-8
Power-Supply Etched-Board Assembly
(P/N 1820-2751)
Connections

Anchor Terminal	Wire Color	Signal	Immediate Connection	Destination (Origin)	Anchor Terminal
2	rd	LINE POWER	S904, 4	(AC Line)	
2L	vt-wh-rd-br	LINE POWER	F902	(AC Line)	
7	gy-wh-vt	Rectifier Input for $\pm$ 100-V P-I Bias	J502-PL502	T901	
8		Rectifier Input for -6-V Bias	J501-PL501	T901	
11	wh-br	Rectifier Input for +15-V Bias	--	T901	
12	wh-rd	Rectifier Input for +100-V Ref Supply	--	T901	
13	wh-or	Rectifier Input for -100-V Ref Supply	--	T901	
14	wh-ye	Input to Rectifier for DC Amp	--	T901	
15	wh-gn	Power	--		
16	wh-bu	-28 V	Q502, C		
17	wh-vt	-33 V	C503, case		
18	wh-gy	+100 V $\pm$ 0.03% REF	AT218	Sweep +100-V Bus	
21	bu	+15-V LAMP SUPPLY	AT227	- Slope Compensator	
22	gn	+15-V BIAS	SO901, 23	Plug-In Ref	
23	wh-rd-bk		AT415	3RD DCU	
501	--		AT104, 221	All +15-V Buses	
502	--		307, 407, 715, 815, SO901, 10		
503	rd		SO901, 17	P-I +100-V Bus	
	ye		SO901, 6	P-I -100-V Bus	
504	wh-gn-bu-bk		Q901, E		
	wh-gn		Q901, B		
505	--		AT116, 355, 654	All -6-V Buses	
506	--		862, SO901, 21		
507	wh-rd		C513, A, B, and Term		
508	wh-br		Q509, C		
509	wh-vt		AT111, 207, 228, SO901, 11	Sweep -Ref Bus	
			AT526	+100-V Ref Supply	
510	--				
511	--				
512	bk				
514	wh-or				
515	--				
516	--				
517	--				
522	--				
523	--				
524	--				
525	--				
526	--				
527	--				
528	wh-gy-bu				
527	wh-gy-rd				
530	gy				

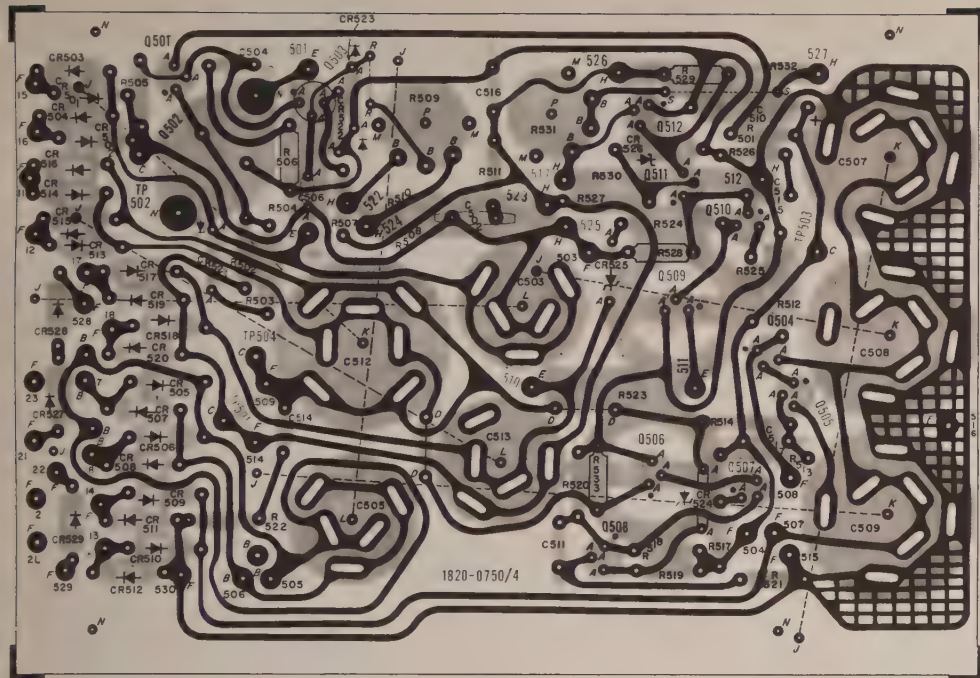
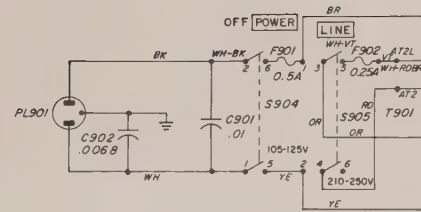


Figure 6-10a. Power-Supply Etched-Board Assembly (P/N 1820-2751).

NOTE: The number appearing on the foil side is not the part number.
The dot on the foil at the transistor socket indicates the collector lead.



NOTE: FOR LINE VOLTAGE OF 210-250V
REMOVE VT WIRE FROM T901, 2L B
SOLDER TO T901, 2. SET S905 TO
210-250

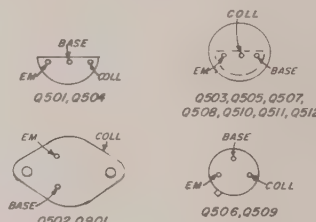
LINE
105 125
210 250 S905
50-60Hz

ALL MEASUREMENTS MADE AT 115V LINE.
VOLTAGES ARE NOMINAL AND MAY VARY 20%

Figure 6-10b. Power-Supply Schematic Diagram.

NOTE: UNLESS SPECIFIED
1. POSITION OF ROTARY SWITCHES
SHOWN COUNTERCLOCKWISE
2. CAPACITANCE VALUES ONE AND
OVER IN MICROFARADS LESS
THAN ONE IN MICROFARADS
3. RESISTANCE IN OHMS
4. CAPACITANCE VALUES ONE AND
OVER IN MICROFARADS LESS
THAN ONE IN MICROFARADS
5. RESISTANCE IN OHMS
6. CAPACITANCE VALUES ONE AND
OVER IN MICROFARADS LESS
THAN ONE IN MICROFARADS
7. KNOB CONTROL
8. SCREWDRIVER CONTROL
9. AT-ANCHOR TERMINAL
10. TP-TEST POINT

TRANSISTORS
BOTTOM VIEW



Type 1820-P1

DC MULTIMETER/UHF VOLTMETER

P/N 1820-9601

(Used only in the Type 1820 Digital Voltmeter)

Contents

Section 1 — Introduction	1
Section 2 — Operating Procedure	3
Section 3 — Principles of Operation	7
Section 4 — Service and Maintenance	9
Section 5 — Parts Lists and Diagrams	15

CHANGE NOTICE INSTRUCTION MANUAL

TYPE 1820-P1 DC MULTIMETER/UHF VOLTMETER

ID-2475

- Page 1. Figure 1-1. General Radio does not supply the two leftmost probes in the photograph.
- Page 11. Paragraph 4.3.5a, add; "Set AC ZERO (see paragraph 2.5.1).".
- Page 12. Paragraph 4.5.1, add; "There are no dc adjustments in the 1820-P1; such corrections are made in the 1820-A".
- Page 13. Paragraph 4.5.2; after sub-paragraph c in the left column, substitute the following for the remainder of paragraph 4.5.2:
- d. Set the input to 1.6 V and the 1820-A to the 20-V full scale range. Adjust the AC ZERO control for an indication of 01.60 V.
 - e. Change the 1820-A to 20-V ac range. Using a 200-V, 1-kHz ac source and the voltage divider, obtain a 20-V ac input to the 1820. The indication should be within 0.1 V of the input.
 - f. Change the range to 200-V ac. The indication should now be within ± 0.28 V of the input.

NOTE

There is no adjustment on the 20- or 200-V ac ranges; nor will the instrument read zero with zero input. This is normal.

The 2-V ac range has the following adjustments: R218 is a zero adjustment, R221 is the gain control, and R231 is the linearity adjustment. The adjustment procedure for the 2-V range is as follows:

- a. Adjust R218 so that the instrument reads zero with no input.

NOTE

It is important that the front-panel AC ZERO control not be touched (after setting as in 'd' above) while the 2-V range is being adjusted. Eventually the AC ZERO control will be used to set the zero of the instrument, but not during this adjustment.

- b. Set the gain control (R221) so that a 2-V input results in a 2-V reading (on the 2-V range). R218 and R231 can be adjusted together, so that 0.2-V ac and 0.4-V ac are read correctly. The instrument should continue to read zero (0000 or 0001) with no input. Repeat the procedure until all readings are correct.

- Page 17. Figure 5-1
On PL902, add a jumper between pins 15 and 31. Delete 'N.C.' near these two pins.

GENERAL RADIO

West Concord, Massachusetts 01781

NEW YORK (N. Y.) 212 964-2722 (N. J.) 201 943-3140 • BRIDGEPORT 203 377-0165 • PHILADELPHIA 215 646-8030 • WASHINGTON, D. C. 301 946-1600 • SYRACUSE 315 454-9323
• ROCHESTER 315 394-2037 • ATLANTA 404 633-6183 • COCOA BEACH 800 241-5122 • HUNTSVILLE 800 241-5122 • BOSTON 617 646-0550 • CHICAGO 312 992-0800
• DETROIT 313 261-1750 • INDIANAPOLIS 317 636-3907 • CLEVELAND 216 886-0150 • DAYTON 513 434-6979 • DALLAS 214 637-2240 • HOUSTON 713 622-7007
• ALBUQUERQUE 505 255-0611 • LOS ANGELES 213 469-6201 • SAN DIEGO 714 232-2727 • DENVER 303 447-9225 • SAN FRANCISCO 415 948-8233 • SEATTLE 206 454-7545
• CANADA • TORONTO 416 247-2171 • MONTREAL 514 737-3673 • OTTAWA 613 233-4237 • EUROPE • ZURICH (051) 47 70 20 • MUNICH (0811) 40 18 17 • LONDON 06285-22567

Specifications



DC VOLTAGE

Range: 220.0 mV to 220.0 V full scale (positive or negative), in four ranges; 1000 V with attenuator.

Impedance: $10^{11} \Omega$, all four ranges; $10^7 \Omega$ on 1000-V range.

Accuracy: $\pm(0.1\%$ of full scale + 100 μ V).

AC VOLTAGE

Range: 2.200 to 220.0 V, full scale reading, in three ranges. Max 200 V (1000 V with attenuator); above 200 MHz, max voltage limit varies inversely with frequency.

Effective Impedance: Approx 25 M Ω across 2 pF with probe.

Accuracy: $\pm(0.4\%$ of reading + 0.1% of full scale), for readings above 10% of full scale, at 1 kHz.

Detector Response: Operates as peak voltmeter calibrated to read rms value of a sine wave or $0.707 \times$ peak of a complex wave.

Waveform Error: For low voltage, the response gradually shifts from peak above 2 V to essentially rms below 200 mV.

Frequency Response: Within 3 dB at 10 Hz and 1.5 GHz; $<1\%$ down at 50 Hz. Probe resonance above 3 GHz.

LOG VOLTAGE FUNCTION

Range: Ac voltage, 6 to 62 dB re 100 mV in 3 ranges. Negative dc voltage, -14 to 62 dB re 100 mV in 4 ranges.

Accuracy: Ac, ± 0.15 dB; neg dc, ± 0.05 dB.

ISOLATION Low input terminal is by-passed and can be floated up to 400 V from ground.

RESISTANCE

Kilohm Range: 0.220, 2.200, 22.00, and 50.00 k Ω full scale.

Megohm Range: 0.220, 2.200, 22.00, and 50.00 M Ω full scale.

Max Test Voltage: -0.22, -2.2, -22, and -50 V, corresponding to above measurement ranges.

Accuracy: $\pm(0.1\%$ of reading + 0.1% of full scale + 100 m Ω) on 0- to 50-k Ω range; $\pm(0.3\%$ of reading + 0.1% of full scale + 100 Ω) on 0- to 50-M Ω range.

Noise: Less than one-half of least significant digit on most sensitive linear range.

Speed (dc, filter on min): Approx 40 ms for a step of up to 10% full scale; 70 ms for full-scale step; 200 ms per range for greater-than-full-scale step.

Input Filter: Four time constants, switchable, 10, 33, 100, and 300 ms.

Accessories Supplied: Probe accessories.

Accessories Available: 1806-P1 Tee for high-frequency voltage measurements.

Terminals: Front-panel input, probe and binding posts.

NOTES, CAUTIONS, AND WARNINGS

WARNING – HIGH VOLTAGE

Voltages up to 1,000 V can be measured with this instrument, and such voltages are extremely dangerous. Be sure to exercise considerable caution when making connections or when operating the voltmeter for any high-voltage measurements. The connecting link must always be securely in place except for ungrounded operation as noted below.

CAUTION – UNGROUNDED OPERATION

When the connecting link between the bottom (low) and the metallic (chassis ground) INPUT terminal is removed, do not connect a signal that has an ac voltage component to the low terminal.

When the link is removed, a signal that is as much as 400 Vdc from ground can be applied to the low terminal.

WARNING – UNGROUNDED OPERATION

Be sure the probe is in its storage socket to avoid damage to equipment or injury to personnel by accidental contact with the ground shell of the probe, which is permanently connected to the bottom (low) binding post.

Be sure that the third wire of the instrument's power cord is grounded.

CAUTION – HIGH-FREQUENCY PROBE

Do not apply more than 200 V rms sinewave, or 280 V, peak, to the probe of the Type 1820-P1. Do not apply more than 600 V dc to the probe.

At frequencies above 200 MHz the voltage applied to the probe must be reduced in inverse proportion to the frequency. The maximum voltage applied to the probe should be limited as follows:

<i>Frequency</i>	<i>Maximum Voltage</i>
200 MHz	200 V
500 MHz	60 V
1000 MHz	30 V

NOTE

A test voltage is applied by the Type 1820 across the INPUT terminals when the MEASUREMENT switch is in an Ω position. This voltage is not dangerous, but may give the operator a mild shock on contact; therefore, it is better to connect the resistance with the MEASUREMENT switch in the AC or DC position, then switch to an Ω position.

Section 1—Introduction

1.1 PURPOSE.....	1
1.2 DESCRIPTION.....	1
1.3 ACCESSORIES SUPPLIED	1
1.4 ACCESSORIES AVAILABLE	2
1.5 CONTROLS AND CONNECTORS	2

1.1 PURPOSE.

The Type 1820-P1 DC Multimeter/UHF Voltmeter is a high-frequency, ultra-high input impedance plug-in unit for the Type 1820-A Digital Voltmeter. With it, ac measurements up to 1 GHz, dc measurements with a maximum full-scale sensitivity of 200 mV, and resistance measurements can be made. Digital read-out is linear or logarithmic in three ac ranges (2.2, 22, and 220 V) and four dc ranges (also 220 mV). Input impedance is greater than $10^{11} \Omega$ (10^7 with X100 ATT) for dc measurements on all ranges, 25 M Ω for ac. The unit has a X100 attenuator that can be switched in for measurements from 200 to 1000 V, a variable-time-constant input filter, and floatable input terminals. No other attenuator is introduced on any range of the Type 1820-P1.

1.2 DESCRIPTION.

The Type 1820-P1 consists of a field-effect-transistor preamplifier preceded by a photochopper assembly and an RC input filter.

A probe containing a vacuum diode rectifies the ac signal for ac voltage measurements. A linearizer network in the preamplifier and an rms multiplier in the sweep circuit compensates the signal applied to the main-unit comparator circuits for the probe voltage-current and response characteristics.

For resistance measurements, a reference current is connected across the input terminals so that the unknown resistance can be determined by the measurement of the voltage drop across it.

1.3 ACCESSORIES SUPPLIED.

Quantity	Description	Part Number
1	Accessory set of probe-tip connectors and ground clips for ac probe (Figure 1-1).	1800-3510
1	Instruction book	1820-0110

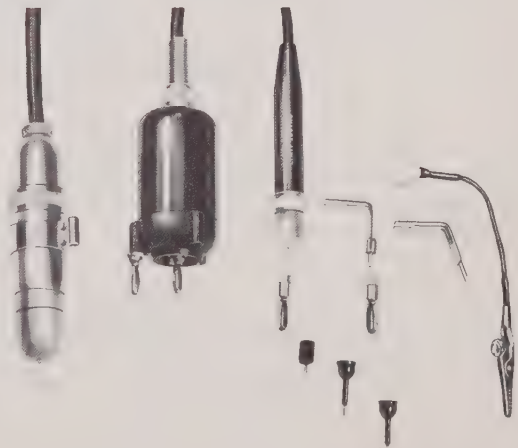


Figure 1-1. The probe and various tip and ground-clip accessories.

1.4 ACCESSORIES AVAILABLE.

For measurements at frequencies greater than several hundred megahertz, the Type 1820-P1 Tee Connector (Figure 1-2) is an essential accessory. It allows the probe to be connected across a 50- Ω coaxial line with minimum disturbance to the system.

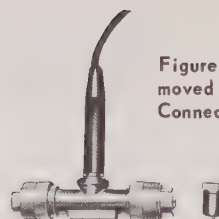
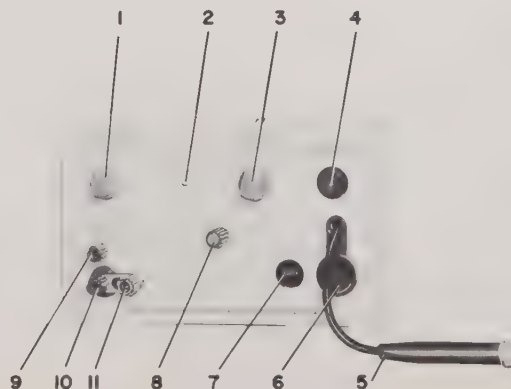


Figure 1-2. The probe with tip removed and the Type 1806-P1 Tee Connector screwed in its place.

1.5 CONTROLS AND CONNECTORS.

Ref. No (Figure 1-3)	Name	Description	Function
1	MEASUREMENT selector	4-position rotary switch	Determines whether instrument is to measure ac voltage (AC), dc voltage (DC), or resistance (0-50 k Ω or 0-50 M Ω).
2	VOLTS switch	2-position, screwdriver operated switch	Determines input attenuation; no attenuation in the NORM position; X100 attenuation in X100 ATT position (to be used only when input voltage exceed 220 V) which extends meter range to 1000 V.
3	INPUT FILTER TIME CONSTANT selector	4-position rotary switch	Selects time constant for input filter, which attenuates input noise. Time constants are approximately, 10 ms (MIN), 33 ms, 100 ms, and 300 ms (MAX).
4	AC ZERO adjustment	Thumb control, rotary	For setting ac zero on 2-V range with input open or short circuited.
5	AC voltage probe CAUTION: Do not apply more than 200 V to this probe.	High-frequency, 25-M Ω rectifying probe, with 3-ft cable, GR Part No. 1800-3500	For measuring high-frequency ac voltages. To measure ac voltages greater than 200 V, leave the probe in its storage socket, connect the UNKNOWN to input terminals (9 and 10 in Figure 1-3) so the attenuator can be used.
6	Probe storage socket	Special recessed jack that mates with ac probe, GR Part No. 1806-1000	For storage of ac probe.
7		2-connector socket, Jones Part No. 5-302-AB	Supplies 15-V bias voltage to Type 1820-P3 Differential Adaptor.
8	Mounting rod	Threaded rod with knob	For mechanical connection to Type 1820.
9,10	Input terminals, high (9) and low (10)	Type 274 insulated 3/4-in spaced binding-post pair	For application of UNKNOWN dc voltage, resistance, or low-frequency ac voltage.
11	Ground terminal	Type 274 non-insulated binding post	For connection to chassis ground.
not shown	Plug-in unit plugs	24- and 32-connector plugs, Amphenol No's. 26-4100-24P and -32P	For electrical connection to Type 1820-A. Refer to Figure 5-2 for a listing of pin function.

Figure 1-3. Control and connectors of the Type 1820-P1.



Section 2—Operating Procedure

2.1 INSTALLATION	3
2.2 VOLTAGE SWITCH.....	3
2.3 INPUT FILTER TIME CONSTANT SWITCH ..	3
2.4 DC VOLTAGE MEASUREMENTS	3
2.5 AC VOLTAGE MEASUREMENTS	4
2.6 RESISTANCE MEASUREMENTS	5
2.7 DISPLAY	5
2.8 DC CURRENT MEASUREMENTS	6

2.1 INSTALLATION.

Turn the POWER switch on the main frame OFF. Insert the plug-in unit into the main frame and press it in until the front panels are flush. Tighten the knurled screw in the center of the plug-in to secure it to the main frame.

2.2 VOLTAGE SWITCH.

The VOLTAGE switch is a screwdriver operated attenuation selector, which in the X100 ATT position inserts an attenuator between the input terminals and the rest of the Type 1820-P1 circuitry as shown in Figure 2-1. As the figure indicates, this attenuator does not affect resistance measurements.

Leave the switch in the NORM position, except when the input signal level exceeds 220 V dc or rms. When the signal exceeds this level, it must be applied to the INPUT terminals, the probe must be left in its socket, and the input-attenuation selector set to X100 ATT. Otherwise, overload and possible damage to the Type 1820-P1 may result.

CAUTION

Do not apply more than 1000V dc or rms to the instrument.

2.3 INPUT-FILTER TIME-CONSTANT SWITCH.

Set the INPUT-FILTER TIME-CONSTANT switch to MIN for resistance measurements and ordinary dc and ac voltage measurements.

If the input signal is especially noisy, increase the input-filter time-constant one step at a time until the digital display stabilizes. The time constants are, from MIN to MAX, approximately 10, 33, 100, and 300 ms.

2.4 DC VOLTAGE MEASUREMENTS.

2.4.1 CONNECTIONS.

Make all dc voltage measurements with the voltage source connected to the input binding posts on the front panel of the plug-in unit or on the rear of the main frame. The top binding post is the high terminal;

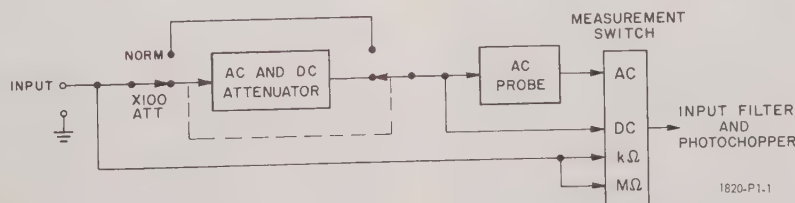


Figure 2-1. Block diagram of INPUT-attenuation switch.

the bottom insulated binding post is the low terminal. The link is used to connect the low terminal to the metallic binding post, which is the cabinet and the third-wire ground connection. With the MEASUREMENT knob in the DC position, the digital indicators will display the voltage at the top binding post with respect to that at the bottom. The bottom binding post is the low terminal in the sense that it has much greater capacitance to the case ground than has the top binding post.

WARNING

Voltages up to 1000 volts can be measured with this instrument, and such voltages are extremely dangerous. Be sure to exercise considerable caution when making connections or when operating the voltmeter for any high-voltage measurements. The third wire of the Type 1820-A power cord should always be grounded.

2.4.2 UNGROUNDED OPERATION.

To use the voltmeter with neither INPUT terminal grounded, remove the link between the bottom and the metal binding posts. The low terminal (bottom) can then be connected to a circuit point that is as much as 400 V dc from ground. A 1.0- μ F capacitor bypasses the low input terminal to the grounded cabinet at all times. Do not connect the low terminal to a voltage that has an ac component with respect to ground. Removal of the link is intended only for connection of the low terminal to a point whose voltage differs from ground by dc, not by ac. When the link is removed for the purpose of making dc-off-ground measurements, be sure the probe is in its storage socket to avoid damage to equipment or injury to personnel by accidental contact with the ground shell of the probe, which is permanently connected to the low (bottom) binding post.

2.5 AC VOLTAGE MEASUREMENTS.

2.5.1 AC ZERO.

To adjust the AC ZERO, set the FUNCTION switch on the main frame to LIN, short the input terminals, and set the AC ZERO control so that the digital display alternates between 0000 and 0001, with the greater amount of time being spent in the former state. This procedure is necessary because the counter, on its lowest range, will display 0000 for all settings of the AC ZERO beyond the proper one, which puts the display just at 0000.

For a limited range, this adjustment is coarse when turning clockwise and fine when turning counter-clockwise.

2.5.2 CONNECTIONS.

There are two ways to measure ac voltages. The probe can be removed from its socket and connected directly to the circuit point of interest or the probe can be placed in its storage socket and the ac voltage can then be applied to the input binding posts. The maximum voltage that should be applied directly to the probe is 200 V rms sinewave, or 280 V peak. For the measurement of ac voltages over 200 V rms place the probe in its storage socket and connect the input to the input binding posts.

CAUTION

Do not apply ac signals of more than 200 V rms or 280 V peak to the probe. Do not apply more than 600 V dc to the probe.

2.5.3 PROBE ACCESSORIES.

Several different ground connection devices and probe tip connectors are supplied with the instrument. Select the most convenient of these devices for the high and ground connections to the probe. Some of the possible combinations are shown in use in Figure 2-2. Connect the shell of the probe to the electrical ground and the tip to the circuit point at which the voltage is to be measured.

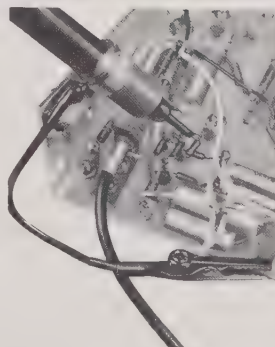
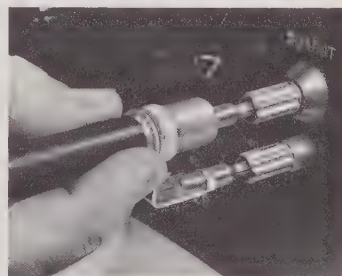
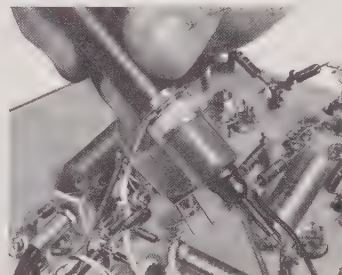


Figure 2-2. Some of the ways in which the probe can be directly connected to a circuit for ac voltage measurements.

2.5.4 FREQUENCY RESPONSE.

Measurements at frequencies exceeding 500 kHz, should be made by direct connection to the probe. With the probe connected directly to the point of interest, voltages at frequencies of the order of several hundred MHz can be measured, but appreciable errors may appear, depending on the method of connection. For best results, keep the tip and ground connections as short as possible.

For higher frequencies, the Type 1806-P1 Tee Connector (Figure 1-2) must be used. This connector permits bridging of a 50-ohm coaxial line by the probe, with little disturbance to the circuits, at frequencies up to 1500 MHz. Refer to the specifications for the voltage accuracy and standing-wave-ratio performance of this connector.

To install the Tee Connector, first unscrew the gray plastic probe tip by means of the knurled ring at the base of the tip. At the same time, pull on the cable with the little finger of the hand holding the body of the probe, to draw the inner section of the probe away from the tip (see Figure 2-3). With the probe tip removed, keep the same grip on the body of the probe and screw on the Tee Connector until it is tight. Then release the grip on the cable. The Tee Connector can then be plugged directly into a coaxial circuit by means of the GR874® Locking Connectors. GR874 connectors can be locked on the Type 1806-P1 Tee Connector for convenient use in coaxial systems using other series connectors.



Figure 2-3. Unscrewing the tip from probe. Notice little finger of hand holding cable, to withdraw inner part of probe from tip.

Keep the link connected between the metal and bottom binding posts for all ac measurements. Even when the link is disconnected, there remains an internal 1.0- μ F capacitor connected between the bottom and the metal binding posts, which tends to bypass directly to the power-line ground any ac voltage that might be connect to the bottom binding post.

WARNING

Make sure the third wire is properly grounded; if it is not, the cabinet and the bottom binding post will be at the same ac potential with respect to ground, because of the 1.0- μ F capacitor.

CAUTION

Because of losses due to transit time in the diode, the voltage applied to the probe must be reduced at high frequencies. The full low-frequency rating of 200 V rms may be applied at frequencies below 200 MHz. At higher frequencies, the voltage should be reduced in inverse proportion to the frequency. The maximum voltage applied to the probe should therefore be limited as follows:

Frequency, MHz	Maximum Voltage, Volts
200	200
500	60
1000	30
1500	20

2.5.5 DEPENDENCE OF ACCURACY UPON WAVEFORM.

This plug-in unit is essentially a peak-measuring instrument for ac voltages, but its output is proportional to the rms value of a sinewave input signal. The operation of the voltmeter may be more accurately described as measuring the height in volts of the positive peak of the input voltage above its average, and it is calibrated to indicate 0.707 of this value. It should be kept in mind that the presence of harmonic distortion in a periodic input voltage may cause an error in the determination of the rms value as large as the percentage of harmonic distortion. The voltmeter is capable of measuring accurately the amplitude of a periodic rectangular voltage wave whose positive part has a duty ratio as low as 0.001. It should be kept in mind that the indication of an instrument of this type, when it is used to measure a square wave (duty ratio about 0.5), is inversely proportional to the duty ratio, which must therefore be known accurately.

2.6 RESISTANCE MEASUREMENTS.

To measure a resistance, connect it to the input terminals and set the MEASUREMENT switch to k Ω or M Ω . The k Ω ranges are 220.0 Ω , 2.200 k Ω , 22.00 k Ω , and 50 k Ω , full scale. The M Ω ranges are 220.0 k Ω , 2.200 M Ω , 22.00 M Ω , and 50.00 M Ω , full scale.

The dc test voltage (at top terminal) is negative with respect to ground and varies in accordance with the resistance being measured as follows: 0.22 V, 2.2 V, 22 V, and 50 V, full scale for the range segments of each switch setting.

WARNING

DA NGEROUS VOLTAGE COULD BE EXPOSED

For measurements of resistance above 50 M Ω and up to 200 M Ω , the neon bulb V902 can be disconnected. However, care must be exercised in these measurements, because 300 volts may appear across the input terminals. Although these voltages are not lethal, they can cause severe shocks.

2.7 DISPLAY.

The Type 1820 will display the measured quantity with its polarity, the unit of measurement (V, mV, k Ω , M Ω , or dB), and decimal point location. This information will also be available in BCD form at the DATA OUTPUT socket at the rear of the main frame.

NOTE

Measurement results in the lowest logarithmic range, corresponding to input voltages between 20 and 126 mV (-14 dB to +2 dB re 100 mV), will be displayed with a +60-dB offset, that is, 60 dB must be subtracted from the measurement in this range to obtain the correct signal level. For example, the counter is in its lowest range and the display reads 40.00 dB. The signal level is 40.00 dB - 60.00 dB = -20.00 dB. For ac, 200 mV is the minimum level that can be measured.

Table 2-1 lists the results of log mode measurements made by the Type 1820-A with the Type 1820-P1.

2.8 DC CURRENT MEASUREMENTS.

The voltmeter can be used to measure small direct currents as follows: Set the MEASUREMENT switch to DC, connect a shunt resistor across the IN-

PUT terminals, and connect the current source across the resistor. Table 2-2 gives full scale current ranges equivalent to the various full scale voltage ranges of the Type 1820-P1.

Table 2-1

LOG Voltage Measurement with the Type 1820-P1 Plug-In			
<i>V_{input}</i> (AC or DC)	<i>Display</i> (dB)	<i>Actual</i> <i>Count*</i>	<i>Range</i> <i>Count*</i>
20.0 mV**	46.00 (46 - 60 = -14)	0600	000
31.6 mV**	50.00 (50 - 60 = -10)	1000	000
100.0 mV**	60.00 (60 - 60 = 0)	2000	000
126.0 mV**	62.00 (62 - 60 = +2)	2200	000
126 mV	02.00	0200	101
316 mV	10.00	1000	101
1.0 V	20.00	2000	101
1.26 V	22.00	2200	101
1.26 V	22.00	0200	011
3.16 V	30.00	1000	011
10.0 V	40.00	2000	011
12.6 V	42.00	2200	011
12.6 V	42.00	0200	001
31.6 V	50.00	1000	001
100.0 V	60.00	2000	001
126.0 V	62.00	2200	101

*BCD output.

**Negative DC ONLY

Table 2-2

Equivalent Full-Scale Current Ranges			
<i>Shunt</i> <i>Resistor</i>	<i>Voltage (full scale) / Current (full scale)</i>		
100 MΩ	220 mV / 2.2 nA	2.2 V / 22 nA	22 V / 220 nA
10 MΩ	220 mV / 22 nA	2.2 V / 220 nA	22 V / 2.2 μA
1 MΩ	220 mV / 220 nA	2.2 V / 2.2 μF	22 V / 22 μA
100 kΩ	220 mV / 2.2 μA	2.2 V / 22 μA	22 V / 220 μA
10 kΩ	220 mV / 22 μA	2.2 V / 220 μA	22 V / 2.2 mA

Section 3—Principles of Operation

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3.1 GENERAL.

Figure 3-1 is a block diagram of the Type 1820-P1. The input signal passes through the INPUT attenuation selector and input filter to the photochopper assembly where it is chopped and amplified by a factor of seven in FET amplifier. The output of this amplifier is applied to a series of amplifier stages in the Type 1820 main unit. From one of the stages, selected by the range-changing relays of the main unit, a feedback signal is taken and applied to the photochopper. This feedback raises the input impedance of the voltmeter

to $10^{11} \Omega$ or more, when the input X100 attenuator is not in use.

For ac measurements, the input is applied directly to the diode in the ac probe, the ac linearizer is connected into the feedback loop, the rms multiplier is inserted in the negative-sweep circuit in the main unit, and the feedback voltage is connected to the photocells via a 9-V floating power supply. For resistance measurements, the feedback voltage is fed both to the photochopper via the 9-V floating supply and to the INPUT terminals, where it serves as the test voltage across the unknown resistance. The individual circuits and their functions are described in the following paragraphs.

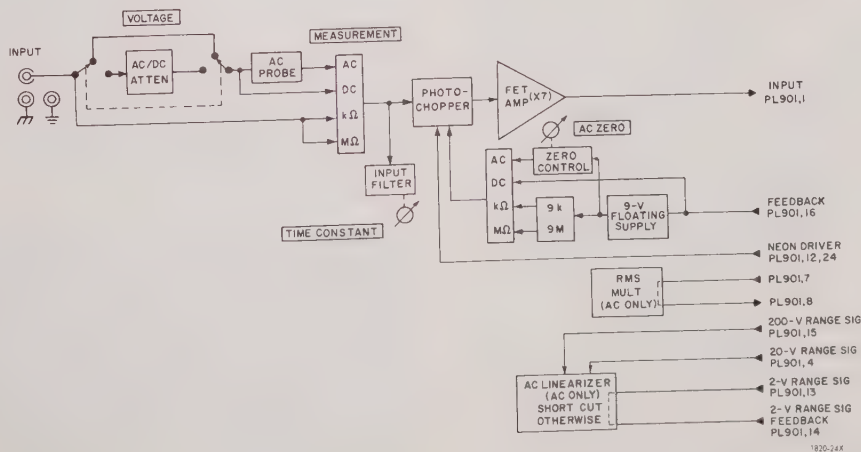


Figure 3-1. Block diagram of the Type 1820-P1.

3.2 INPUT CIRCUITS.

The input circuits consist of the input attenuators, the ac probe, and the variable-time-constant input filter. The filter is preceded by a 10-M Ω resistor R101, which functions as part of the filter and also protects the chopper and preamplifier circuits from overload. This resistor does not introduce any significant error, since its resistance is small compared to the input impedance of the instrument ($>10^{11} \Omega$).

There are two voltage attenuators selected by the INPUT Attenuation Selector S902, a resistive divider for dc and a capacitive divider for ac. When the input attenuation selector is set to X100, the input impedance is 10 M Ω for dc measurements and about $3 \times 10^3/f$ M Ω (10 M Ω at 300 Hz) for ac measurements. Each attenuator has an adjustment with which precise calibration for high-voltage signals can be obtained.

The probe rectifier circuit is shown in Figure 3-2. A small dc bias voltage is applied to the shunt resistor R1 to standardize the rectification efficiency at low voltage levels. This bias voltage is adjustable by means of R204 in the plug-in unit.

The input filter is the simplest kind of RC combination, the R of which is R101. The capacitance is determined by the setting of S903, the INPUT FILTER TIME CONSTANT selector.

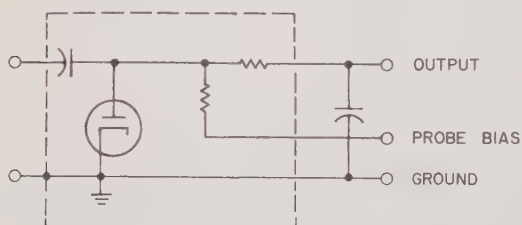


Figure 3-2. Schematic diagram of probe circuit.

3.3 PHOTOCCHOPPER ASSEMBLY AND PREAMPLIFIER.

The photochopper assembly is a series-shunt combination (see Figure 3-3) with the input signal applied to the series element and feedback from the main amplifier applied to the shunt element. The resistance of the photoresistors is alternately reduced by the application of light to their surfaces from two neon lights through a light-pipe assembly. The bulbs are driven by an oscillator in the main frame. Under normal operating conditions, the photochopper effi-

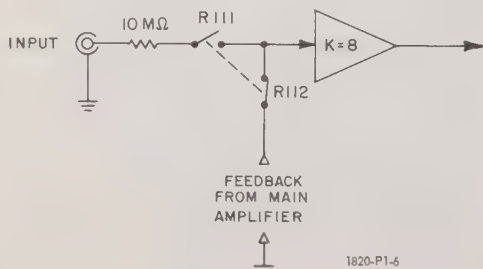


Figure 3-3. Equivalent circuit of the photochopper.

ciency, at a frequency of 300 Hz, is 70 to 90% (peak-to-peak ac output to dc input).

The preamplifier is a two-stage feedback amplifier. The first stage is an N-type FET. The gain of this unit is about 7.

3.4 RESISTANCE MEASUREMENT.

Resistance measurements are made with the Type 1820-P1 by measurement of the voltage produced across the unknown by an internal current source. This source is a very stable 9.4-V floating supply connected in series with resistor R, as shown in Figure 3-4. R is 8.8 k Ω for k Ω measurements and 8.8 M Ω for M Ω measurements. One end of the floating supply is connected to the feedback circuit, so that regardless of the input voltage (on which the feedback voltage depends) a constant current is supplied to the load R_x . This current i_x , which is 1 mA for k Ω measurements and 1 μ A for M Ω measurements, also flows through the range-setting resistors R159, R161, R163, and R164, depending on the range in use. R160 and R162 cancel the effect of the voltage drop across these resistors. This method of resistance measurement is best suited for measuring high values, although, because of the very high input impedance of the amplifier, low values can also be measured.

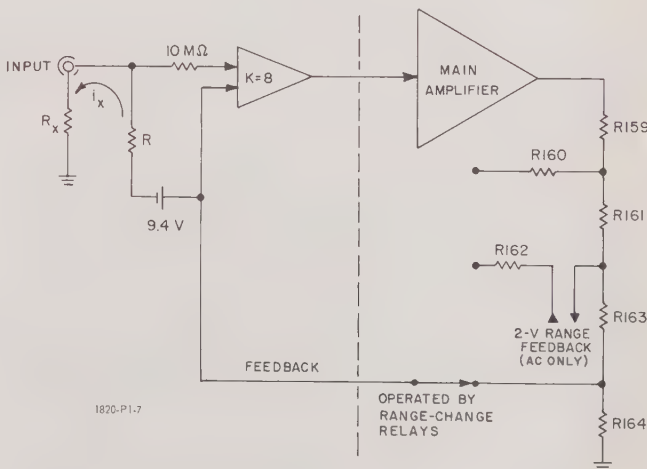


Figure 3-4. Equivalent circuit of resistance-measuring network.

3.5 COMPENSATION CIRCUITS FOR AC MEASUREMENTS.

The response of the rectifying diode in the ac probe is not entirely linear, so a set of compensating networks, switched in and out by the range-change relays, is inserted in the feedback loop when the MEASUREMENT switch is set to AC. These networks comprise diodes CR202 through CR207 and their associated resistors as shown in Figure 6-1. Also, a resistive divider, R332, R333, and R336, is inserted between the negative sweep circuit and its comparator in the main frame to produce an rms reading for sine-wave measurements or 0.707 of the peak value of complex waves.

Section 4—Service and Maintenance

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4.1 WARRANTY.

We warrant the each new instrument manufactured and sold by us is free from defects in material and workmanship, and that, properly used, it will perform in full accordance with applicable specifications for a period of two years after original shipment. Any instrument or component that is found within the two-year period not to meet these standards after examination by our factory, District Office, or authorized repair agency personnel, will be repaired, or, at our option, replaced without charge, except for tubes or batteries that have given normal service.

4.2 SERVICE.

The two-year warranty stated above attests the quality of materials and workmanship in our products. When difficulties do occur, our service engineers will assist in any way possible. If the difficulty cannot be eliminated by use of the following service instructions, please write or phone our Service Department (see rear cover), giving full information of the trouble and of steps taken to remedy it. Be sure to mention the serial and type numbers of the instrument.

Before returning an instrument to General Radio for service, please write to our Service Department

or nearest District Office, requesting a Returned Material Tag. Use of this tag will ensure proper handling and identification. For instruments not covered by the warranty, a purchase order should be forwarded to avoid unnecessary delay.

4.3 MINIMUM PERFORMANCE STANDARDS.

4.3.1 GENERAL.

The procedures outlined in the following paragraphs provide a means of testing the accuracy of all the measurements performed by the Type 1820 Digital Voltmeter with the Type 1820-P1 DC Multimeter/UHF Voltmeter plug-in unit. The results of these tests depend on the calibration of the Type 1820-A main frame as well as on that of the plug-in. If recalibration is found to be necessary, refer first to the procedure for the Type 1820-A in the Service and Maintenance section of that manual, then to paragraph 4.5 of this section. For a quick operational check, rather than an accuracy test, refer to paragraph 3.2 in the Type 1820-A instruction-manual section. Table 4-1 lists the tests to be performed in this section.

Table 4-1
Specifications To Be Tested

<i>Measurement</i>	<i>Required Accuracy</i>	<i>Paragraph Number</i>
Power Consumption	±10%	4.3.3
Dc volts - LIN	±0.1% of full scale ±100 μV	4.3.4
- LOG	±0.05 dB (negative dc only)	4.3.4
Ac volts - LIN	±0.4% ±2 counts to 10% full scale at 1 kHz	4.3.5
- LOG	±0.15 dB	4.3.5
kΩ	±0.1% ±2 counts ±100 mΩ	4.3.6
MΩ	±0.3% ±2 counts ±100 Ω	4.3.6
Sampling Rate	±20%	4.3.7

4.3.2 EQUIPMENT REQUIRED.

The equipment required to test whether the Type 1820-P1 DC Multimeter/UHF Voltmeter meets its published specifications is listed in Table 4-2.

4.3.3 POWER CONSUMPTION.

To determine that the Type 1820-A with the Type 1820-P1 consumes the nominal amount of power, use the following procedure.

a. Connect the digital voltmeter to a source of ac power via the metered autotransformer and throw the POWER switch on.

b. Bring the autotransformer voltage up to the nominal value of the voltage range set by the Type 1820 line switch (e.g. 115 V). The power consumed should be 40 W ±10%, as indicated by the autotransformer meter.

4.3.4 DC VOLTS.

The following procedure checks the accuracy of the dc voltage measurements made with the Type 1820-A - 1820-P1 combination.

a. Set the Type 1820 controls as follows:

POWER	on
RANGE	AUTO
SAMPLING RATE	center
FUNCTION	LIN
MEASUREMENT	DC
INPUT VOLTS	NORM

b. Set the dc reference-source voltage to +100.0 mV and connect it to the Type 1820-P1 input terminals.

c. Measure the reference voltages shown in Table 4-3 to be within the limits (LIN) indicated.

d. Set the INPUT VOLTS switch to X100 ATT and the reference voltage to -200.0 V. The display should be within -1.998 V to -2.002 V in the LIN mode (25.97 dB to 26.07 dB in the LOG mode).

e. Set the FUNCTION switch to LOG and the INPUT VOLTS switch to NORM. Measure the negative dc reference levels given in Table 4-3 to within the display limits (LOG) shown.

Table 4-2
Minimum Performance Test Equipment

<i>Device</i>	<i>Necessary Specifications</i>	<i>Recommended Type</i>
Digital Voltmeter main frame	No substitution	GR 1820-A Digital Voltmeter
Metered autotransformer	Variable 0 to 125 V rms with wattmeter	GR W5MT3W Metered Variac® autotransformer
Variable dc Reference-Voltage Source	±20 mV to ±200 V, ±0.05% accuracy.	Fluke Precision Voltage Calibrator Model 337A.
Variable ac Reference-Voltage Source	20-mV to 100 V rms ±0.2% accuracy.	Ballantine Model 421A Dc/Ac Precision Calibrator.
Precision resistors ±0.1% accuracy. Values:	10 Ω 1 kΩ 50 kΩ 1 MΩ 10 MΩ	GR 500-B Resistor GR 500-H Resistor GR 500-T Resistor GR 500-X Resistor GR 500-ZZ Resistor
Oscilloscope (optional) Dc-coupled, medium bandwidth, single trace		Tektronix Model 531 Oscilloscope with a Type K Plug-In Unit.

Table 4-3 DC Accuracy Check		
Set Reference (V)	Display Limits (LIN)	Display Limits (LOG)
+0.100	+099.7 mV to +100.3 mV	
+1.000	+0.998 V to +1.002 V	
+10.00	+09.98 V to +10.02 V	
+100.0	+099.8 V to +100.2 V	
-0.100	-099.7 mV to -100.3 mV	59.95 dB to 60.05 dB
-1.000	-0.998 V to -1.002 V	19.95 dB to 20.05 dB
-10.00	-09.98 V to -10.02 V	39.95 dB to 40.05 dB
-100.0	-099.8 V to -100.2 V	59.95 dB to 60.05 dB

4.3.5 AC VOLTS.

The following procedure checks the accuracy of ac voltage measurements made with the Type 1820-A — Type 1820-P1 combination.

a. Set the Type 1820 controls as in paragraph 4.3.3 step a, except set the MEASUREMENT switch to AC.

b. Set the ac reference-source voltage to 1.000 V rms at a frequency of 1 kHz and connect it to the Type 1820-P1 input.

c. Measure the reference voltages shown in Table 4-4 to be within the indicated limits.

d. Set the INPUT VOLTS switch to X100 ATT and the reference to 200.0 V rms. The display should be between 1.990 V and 2.010 V in the LIN mode (or 25.87 dB to 26.17 dB in the LOG mode).

e. Set the MEASUREMENT switch to LOG and the INPUT VOLTS switch to NORM and measure the voltage levels given in Table 4-4 to be within the indicated limits.

Table 4-4 AC Accuracy Check		
Set Reference (V, rms)	Display Limits (LIN)	Display Limits (LOG)
1.000	0.994 V to 1.006 V	19.85 dB to 20.15 dB
10.00	09.94 V to 10.06 V	39.85 dB to 40.15 dB
100.0	099.4 V to 100.6 V	59.85 dB to 60.15 dB

4.3.6 RESISTANCE.

The following procedure test the accuracy of resistance measurements made by the Type 1820-A with the Type 1820-P1.

a. Set the controls as they were in paragraph 4.3.4 step a, except set the MEASUREMENT switch to k Ω .

b. Connect in succession each of the resistors listed in Table 4-5 to the input terminals of the Type 1820-P1. The resistance values measured should be within the limits given in the k Ω -Range column of the table.

c. Set the MEASUREMENT switch to M Ω and measure the resistance given in Table 4-5 to be within the limits listed in the M Ω -Range column.

Table 4-5 Ω Accuracy Check		
Standard Resistance	Display Limits k Ω Range	Display Limits M Ω Range
10 Ω	009.7 Ω — 010.3 Ω	
1 k Ω	0.997 k Ω — 1.003 k Ω	
50 k Ω	49.93 k Ω — 50.00 k Ω	
1 M Ω		049.6 k Ω to 050.4 k Ω
10 M Ω		0.995 M Ω to 1.005 M Ω
		09.95 M Ω to 10.05 M Ω

4.3.7 SAMPLING RATE.

This procedure is an optional check on the existence of the print command pulse and on the effectiveness of the SAMPLING RATE control.

a. Set the Type 1820 controls as they were in paragraph 4.3.4 step a, except set the SAMPLING RATE control fully counterclockwise. Apply a stable dc voltage to the Type 1820-P1 input.

b. Set the oscilloscope controls as follows:

Triggering Mode	Automatic
Sync Mode	Internal
Input Coupling	Dc
Horizontal Sensitivity	10 ms/div
Vertical Sensitivity	5 V/div

c. Connect the oscilloscope probe to pin A2 of the DATA OUTPUT socket and the oscilloscope ground to the low input terminal of the Type 1820-P1. The display shown in Figure 4-1 should appear. The pulse period (*) should be about 33 ms $\pm$ 20%.

d. Rotate the SAMPLING RATE control slowly clockwise and note that the time separation (*) between the 15-ms -10-V pulses increases.

4.4 ACCESS TO COMPONENTS.

To obtain access to the components of the Type 1820-P1 while it is in operation, remove the cover of the Type 1820 Digital Voltmeter mainframe according to the directions given in Section 2 of its instruction manual. Figure 4-2 shows the location of anchor terminals, test points, and adjustable components.

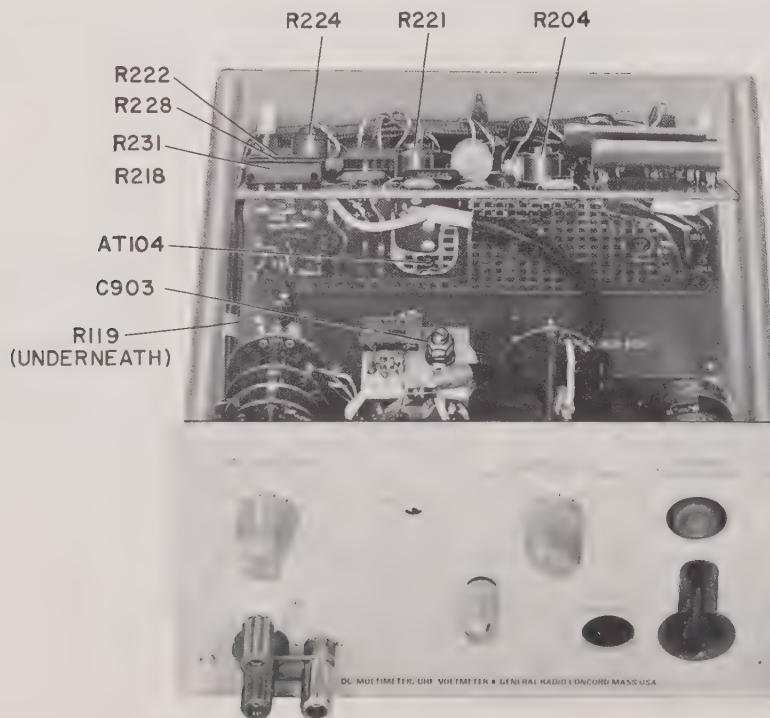


Figure 4-2. Interior view showing test points and secondary controls.

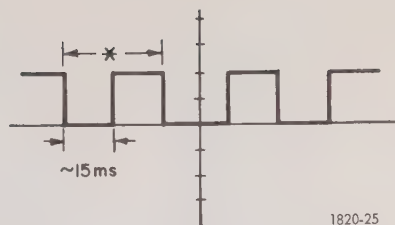


Figure 4-1. The print-command pulse.

To lift the boards up as shown in Figure 4-2, remove the two front corner screws from the top board and tip it up, then remove the four corner screws from the lower board and tip it up as far as possible, being careful not to break any of the connected wires. It is usually necessary to tip up only the top board. Access to the lower board should be made only with the POWER OFF.

4.5 CALIBRATION PROCEDURE.

4.5.1 EQUIPMENT REQUIRED.

The equipment required to calibrate the Type 1820-P1 is listed in Table 4-6.

4.5.2 GENERAL PROCEDURE (Figure 4-2).

If all the adjustments on the main instrument have been performed, the adjustments on the plug-in unit can be made. Before any ac adjustments are made, however, the instrument should be on for at

Table 4-6
Equipment Required For Calibration

<i>Device</i>	<i>Necessary Specifications</i>	<i>Recommended Type *</i>
Digital-Voltmeter main frame	No substitutions	GR 1820-A Digital Voltmeter
Reference-Voltage Supply	Stable dc source, adjustable to produce + and -200.00 V $\pm 0.05\%$.	Fluke Precision Voltage Calibrator Model 332A
Dc Voltmeter	Accurate to $\pm 0.05\%$	Fluke Model 881A Dc Differential Voltmeter.
100-k Ω decade divider	$\pm 0.05\%$ accuracy	GR 1454-AH Decade Voltage Divider
Precision resistor	1-k Ω $\pm 0.05\%$ resistance	GR 500-H Resistor
Sine-wave oscillator	Capable of producing a 0.2-V and a 200-V output at 1 kHz.	GR 1308 Audio Oscillator and Power Amplifier.
Vacuum-tube Voltmeter (VTVM)	Input impedance greater than 25 M Ω , $\pm 0.2\%$ accuracy.	GR 1820 Digital Voltmeter
Patch Cords (3)	Double-plug to double-plug	GR 274NPM Double-Plug Patch Cord.

*Or equivalent.

least one-half hour to allow the probe diode, which is a vacuum tube, to stabilize.

Use the following procedure to adjust the Type 1820-P1:

a. Connect the 1820 with plug-in inserted, to an ac power source via the metered autotransformer.

b. Connect the 1-k Ω resistor to the input of the instrument. Set the FUNCTION switch at k Ω . Vary the line voltage from 105 to 125 volts. Adjust R228 so that no variation in the reading of the digital voltmeter is obtained when the line voltage is varied.

c. Connect a very high input impedance dc voltmeter, such as another GR 1820 or a GR 1806 with open grid to AT101 and set the Type 1820 MEASURE-MENT switch to DC. Now, apply 0.2-V, rms, at 1 kHz to the input of the GR 1820 that is being adjusted. Record the dc reading of the voltmeter that is measuring the voltage at AT101. Disconnect the 0.2-V, rms, ac signal and record the dc voltage at AT101 again. The difference between the two readings at AT101 should be 0.125 V. If not, adjust R204 so that this difference is 0.125 V. This is the dc bias adjustment for the probe.

d. Put the digital voltmeter on 20-V ac range. Using a 200-V 1-kHz ac source and the decade box, obtain a 20 V ac input for the digital voltmeter. The front-panel ac zero adjustment may now be used to make the Type 1820 read 20.00 V, exactly. However, for a better resolution of adjustment, it is suggested that the FUNCTION switch be set to LOG and 14 V ac applied to the input of the digital voltmeter. Adjust the front-panel AC ZERO control so that the digital voltmeter reads 42.92 dB. Set the FUNCTION switch back into LINEAR position.

There is no adjustment for the 200-V ac range. The instrument will not read zero on 20.00-V range with zero input. This is quite normal.

The 2-V ac range has the following three adjustments: R231 is a zero adjustment, R221 is the gain control, and R218 is the linearity adjustment. The adjustment procedure for the 2-V range is as follows:

a. First, adjust the zero control (R231) so that with no input, the instrument reads zero.

NOTE

It is very important that the front-panel zero control not be touched while the 2-V range is being adjusted. Eventually the front panel zero control will be used to set the zero of the instrument but not during this adjustment.

b. Then, set the gain control (R221) so that 2-V ac is read correctly on the 2-V range. R218 and R231 may be adjusted together, so that 0.2-V ac and 0.4-V ac are read correctly. Always keep in mind that the instrument should read zero for zero input.

4.5.3 Ω RANGE ADJUSTMENTS.

The resistance-range adjustments are quite simple and can be accomplished as follows:

a. Connect a precision 1-k Ω resistor to the input of the instrument and adjust R222 so that the instrument reads 1.000 k Ω . Of course, the FUNCTION switch must be on k Ω .

b. Connect a 1-M Ω precision resistor to the input of the instrument and adjust R224 so that the instrument reads 1 M Ω (FUNCTION switch on M Ω).

4.5.4 ATTENUATOR ADJUSTMENTS.

R119 is the dc attenuator adjustment and C903 is the ac attenuator adjustment. Although these atten-

uators are intended for voltages above 200 V, up to 1000 V, they may be adjusted at lower voltages, such as 200 V. For example, 200 V dc may be applied to the input of the instrument and R110 adjusted so that when the attenuator switch is on ATT the instrument will read 2,000 V. Similarly, an ac voltage should be applied and C903 adjusted for correct reading of the input voltage.

4.6 TROUBLE ANALYSIS.

4.6.1 AMPLIFIER CIRCUITS (Figure 4-2).

If improper functioning of the digital voltmeter has been isolated by substitution to the Type 1820-P1, or if the symptoms (see Table 5-3 in the Type 1820-A manual) exhibited point to plug-in troubles, proceed as follows:

a. Open the feedback loop by connecting AT104 in the plug-in to ground with a clip lead.

b. Apply a small dc voltage (between 0.1 to 5 V) to the input terminals and look at the signal at AT108 of the plug-in with an oscilloscope. This signal should be a square wave with the corners rounded.

c. If the signal at AT108 does not resemble a square wave, look at the signal at AT103, which should be a square wave with about one seventh the amplitude of the nominal signal at AT108. If this signal is present, remove and test Q102 and Q101.

d. If the photochopper output at AT103 is not as it should be, assuming that the neon-bulb drivers are functioning properly (paragraph 5.7.1 in the Type 1820-A manual), take off the metal cover of the photochopper assembly and check to see that the neon bulbs are firmly against the lucite rods and the rods firmly against the photo resistors. Turn on the instrument and observe whether both neon bulbs are lit. If they are, turn off the power and replace the photochoppers. If they are not, replace or tighten them in their sockets as necessary.

4.6.2 THE COMPENSATION AND Ω -MEASUREMENT CIRCUITS.

a. If Ω and ac voltage measurements are out of tolerance or change with line voltage, adjust R228 in accordance with paragraph 4.5.2, step b. If this adjustment is impossible, measure the voltage across CR201 to be 9.4 V and replace the diode if it is not.

b. If voltage measurements made with the IN-PUT switch in the X100 ATTEN position are inaccurate, adjust the attenuators in accordance with paragraph 5.4.4.

c. If the 0-50-k Ω range is out of tolerance, adjust R222 according to paragraph 4.5.3, step a.

d. If the 0-50-M Ω range is out of tolerance, adjust R274 according to paragraph 4.5.3, step b.

e. If only the ac volts measurements are out of tolerance, refer to paragraph 4.5.2, steps d and e.

Section 5—Parts Lists and Diagrams

FEDERAL MANUFACTURERS CODE

From Federal Supply Code for Manufacturers Cataloging Handbooks H4-1
(Name to Code) and H4-2 (Code to Name) as supplemented through June, 1967.

Code	Manufacturers Name and Address	Code	Manufacturers Name and Address	Code	Manufacturers Name and Address
00192	Jones Mfg. Co., Chicago, Illinois	53021	Sangamo Electric Co., Springfield, Ill. 62705	80583	Hammarlund Co. Inc., New York, N. Y.
00194	Walsco Electronics Corp., Los Angeles, Calif.	54294	Shallcross Mfg. Co., Selma, N. C.	80740	Beckman Instruments, Inc., Fullerton, Calif.
00656	Aerovox Corp., New Bedford, Mass.	54715	Shure Brothers, Inc., Evanston, Ill.	81073	Grayhill Inc., LaGrange, Ill. 60525
01009	Alden Products Co., Brockton, Mass.	56289	Sprague Electric Co., N. Adams, Mass.	81143	Isolantite Mfg. Corp., Stirling, N. J. 07980
01121	Allen-Bradley Co., Milwaukee, Wisc.	59730	Thomas and Betts Co., Elizabeth, N. J. 07207	81349	Military Specifications
01295	Texas Instruments, Inc., Dallas, Texas	59875	TRW Inc. (Accessories Div), Cleveland, Ohio	81350	Joint Army-Navy Specifications
02114	Ferroxcube Corp. of America, Saugerties, N. Y. 12477	60399	Torrington Mfg. Co., Torrington, Conn.	81751	Columbus Electronics Corp., Yonkers, N. Y.
02606	Fenwal Lab. Inc., Morton Grove, Ill.	61637	Union Carbide Corp., New York, N. Y. 10017	81831	Filton Co., Flushing, L. I., N. Y.
02660	Amphenol Electronics Corp., Broadview, Ill.	61864	United-Carr Fastener Corp., Boston, Mass.	81860	Barry Controls Div. of Barry Wright Corp., Watertown, Mass.
02768	Fastex Division of Ill. Tool Works, Des Plaines, Ill. 60016	63060	Victoreen Instrument Co., Inc., Cleveland, Ohio	82219	Sylvania Electric Products, Inc., (Electronic Tube Div.), Emporium, Penn.
03508	G. E. Semiconductor Products Dept., Syracuse, N. Y. 13201	63743	Ward Leonard Electric Co., Mt. Vernon, N. Y.	82273	Indiana Pattern and Model Works, LaPort, Ind.
03636	Grayburne, Yonkers, N. Y. 10701	65083	Westinghouse (Lamp Div), Bloomfield, N. J.	82389	Switchcraft Inc., Chicago, Ill. 60630
03888	Pyrofilm Resistor Co., Cedar Knolls, N. J.	65092	Weston Instruments, Weston-Newark, Newark, N. J.	82647	Metals and Controls Inc., Attleboro, Mass.
03911	Clairex Corp., New York, N. Y. 10001	70485	Atlantic-India Rubber Works, Inc., Chicago, Ill. 60607	82807	Milwaukee Resistor Co., Milwaukee, Wisc.
04009	Arrow, Hart and Hegeman Electric Co., Hartford, Conn. 06106	70563	Amperite Co., Union City, N. J. 07087	83058	Carr Fastener Co., Cambridge, Mass.
04713	Motorola Semi-Conduct Product, Phoenix, Ariz. 85008	70903	Belden Mfg. Co., Chicago, Ill. 60644	83186	Victory Engineering Corp (IVECO), Springfield, N. J. 07081
05170	Engineered Electronics Co., Inc., Santa Ana, Calif. 92702	71126	Bronson, Homer D., Co., Beacon Falls, Conn.	83361	Bearing Specialty Co., San Francisco, Calif.
05624	Barber-Colman Co., Rockford, Ill. 61101	71294	Canfield, H. O. Co., Clifton Forge, Va. 24422	83587	Solar Electric Corp., Warren, Penn.
05820	Wakefield Eng., Inc., Wakefield, Mass. 01880	71400	Bussman Mfg. Div. of McGraw Edison Co., St. Louis, Mo.	83740	Union Carbide Corp., New York, N. Y. 10017
07127	Eagle Signal Div. of E. W. Bliss Co., Baraboo, Wisc.	71590	Centralab, Inc., Milwaukee, Wisc. 53212	84411	TRW Capacitor Div., Ogallala, Nebr.
07261	Avnet Corp., Culver City, Calif. 90230	71666	Continental Carbon Co., Inc., New York, N. Y.	84835	Lehigh Metal Products Corp., Cambridge, Mass. 02140
07263	Fairchild Camera and Instrument Corp., Mountain View, Calif.	71707	Coto Coil Co. Inc., Providence, R. I.	84971	TA Mfg. Corp., Los Angeles, Calif.
07387	Birther Corp., No. Los Angeles, Calif.	71744	Chicago Miniature Lamp Works, Chicago, Ill.	86577	Precision Metal Products of Malden Inc., Stoneham, Mass. 02180
07595	American Semiconductor Corp., Arlington Heights, Ill. 60004	71785	Cinch Mfg. Co. and Howard B. Jones Div., Chicago, Ill. 60624	86684	RCA (Electrical Component and Devices) Harrison, N. J.
07828	Bodine Corp., Bridgeport, Conn. 06605	71823	Darnell Corp., Ltd., Downey, Calif. 90241	88140	Cutler-Hammer Inc., Lincoln, Ill.
07829	Bodine Electric Co., Chicago, Ill. 60618	72136	Electro Motive Mfg. Co., Wilmington, Conn.	88219	Gould Nat. Batteries Inc., Trenton, N. J.
07910	Continental Device Corp., Hawthorne, Calif.	72259	Nytronics Inc., Berkeley Heights, N. J. 07922	88419	Cornell Dubilier Electric Corp., Fuquay-Varina, N. C.
07983	State Labs Inc., N. Y., N. Y. 10003	72619	Dialight Co., Brooklyn, N. Y. 11237	88627	K and G Mfg. Co., New York, N. Y.
07999	Amphenol Corp., Borg Inst. Div., Delavan, Wisc. 53115	72699	General Instrument Corp., Capacitor Div., Newark, N. J. 07104	89482	Holtzer Cabot Corp., Boston, Mass.
08730	Vemaline Prod. Co., Franklin Lakes, N. J.	72765	Drake Mfg. Co., Chicago, Ill. 60656	89665	United Transformer Co., Chicago, Ill.
09213	General Electric Semiconductor, Buffalo, N. Y.	72825	Hugh H. Eby, Inc., Philadelphia, Penn. 19144	90201	Mallory Capacitor Co., Indianapolis, Ind.
09823	Burgess Battery Co., Freeport, Ill.	72962	Elastic Stop Nut Corp., Union, N. J. 07083	90750	Westinghouse Electric Corp., Boston, Mass.
09922	Burndy Corp., Norwalk, Conn. 06852	72982	Erie Technological Products Inc., Erie, Penn.	90952	Hardware Products Co., Reading, Penn. 19602
11599	Chandler Evans Corp., W. Hartford, Conn.	73445	Amperex Electronics Co., Hicksville, N. Y.	91032	Continental Wire Corp., York, Penn. 17405
12498	Teledyn Inc., Crystalonics Div., Cambridge, Mass. 02140	73559	Carling Electric Co., W. Hartford, Conn.	91146	ITT Cannon Electric Inc., Salem, Mass.
12672	RCA Commercial Receiving Tube and Semi- conductor Div., Woodridge, N.J.	73690	Elco Resistor Co., New York, N. Y.	91293	Johanson Mfg. Co., Bonton, N. J. 07005
12697	Clarostat Mfg. Co. Inc., Dover, N. H. 03820	73899	J. F. D. Electronics Corp., Brooklyn, N. Y.	91598	Chandler Co., Wethersfield, Conn. 06109
12954	Dickson Electronics Corp., Scottsdale, Ariz.	74193	Heinemann Electric Co., Trenton, N. J.	91637	Dale Electronics Inc., Columbus, Nebr.
13327	Solitron Devices, Tappan, N. Y. 10983	74861	Industrial Condenser Corp., Chicago, Ill.	91662	Elco Corp., Willow Grove, Penn.
14433	ITT Semiconductors, W. Palm Beach, Florida	74970	E. F. Johnson Co., Waseca, Minn. 56093	91719	General Instruments, Inc., Dallas, Texas
14655	Cornell Dubilier Electric Co., Newark N. J.	75042	IRC Inc., Philadelphia, Penn. 19108	91929	Honeywell Inc., Freeport, Ill.
14674	Corning Glass Works, Corning, N. Y.	75382	Kulka Electric Corp., Mt. Vernon, N. Y.	92519	Electra Insulation Corp., Woodside, Long Island, N. Y.
14936	General Instrument Corp., Hicksville, N. Y.	75608	Linden and Co., Providence, R. I.	92678	Edgerton, Germeshausen and Grier, Boston, Mass.
15238	ITT, Semiconductor Div. of Int. T. and T., Lawrence, Mass.	75915	Littelfuse, Inc., Des Plaines, Ill. 60016	93332	Sylvania Electric Products, Inc., Woburn, Mass.
15605	Cutler-Hammer Inc., Milwaukee, Wisc. 53233	76005	Lord Mfg. Co., Erie, Penn. 16512	93916	Cramer Products Co., New York, N. Y. 10013
16037	Spruce Pine Mica Co., Spruce Pine, N. C.	76487	James Millen Mfg. Co., Malden, Mass. 02148	94144	Raytheon Co. Components Div., Quincy, Mass.
19701	Electra Mfg. Co., Independence, Kansas 67301	76545	Mueller Electric Co., Cleveland, Ohio 44114	94154	Gould Nat. Electric Inc., Newark, N. J.
21335	Fafnir Bearing Co., New Briton, Conn.	76684	National Tube Co., Pittsburg, Penn.	95076	Tung Mfg. Co., Cumberland, R. I.
24446	G. E. Schenectady, N. Y. 12305	76854	Oak Mfg. Co., Crystal Lake, Ill.	95146	Alco Electronics Mfg. Co., Lawrence, Mass.
24454	G. E., Electronic Comp., Syracuse, N. Y.	77147	Patton MacGyver Co., Providence, R. I.	95238	Continental Connector Corp., Woodside, N. Y.
24455	G. E. (Lamp Div), Nela Park, Cleveland, Ohio	77166	Pass-Seymour, Syracuse, N. Y.	95275	Vitramon, Inc., Bridgeport, Conn.
24655	General Radio Co., W. Concord, Mass 01781	77263	Pierce Roberts Rubber Co., Trenton, N. J.	95354	Methode Mfg. Co., Chicago, Ill.
26806	American Zettler Inc., Costa Mesa, Calif.	77339	Positive Lockwasher Co., Newark, N. J.	95412	General Electric Co., Schenectady, N. Y.
28520	Hayman Mfg. Co., Kenilworth, N. J.	77542	Ray-O-Vac Co., Madison, Wisc.	95794	Ansonda American Brass Co., Torrington, Conn.
28959	Hoffman Electronics Corp., El Monte, Calif.	77630	TRW, Electronic Component Div., Camden, N. J. 08103	96095	Hi-Q Div. of Aerovox Corp., Orlean, N. Y.
30874	International Business Machines, Armonk, N.Y.	77638	General Instruments Corp., Brooklyn, N. Y.	96214	Texas Instruments Inc., Dallas, Texas 75209
32001	Jensen Mfg. Co., Chicago, Ill. 60638	78189	Shakeproof Div. of Ill. Tool Works, Elgin, Ill. 60120	96256	Thordarson-Meissner Div. of McGuire, Mt. Carmel, Ill.
35929	Constanta Co. of Canada Limited, Montreal 19, Quebec	78277	Sigma Instruments Inc., S. Braintree, Mass.	96341	Microwave Associates Inc., Burlington, Mass.
37942	P. R. Mallory and Co. Inc., Indianapolis, Ind.	78488	Stackpole Carbon Co., St. Marys, Penn.	96906	Military Standards
38443	Marlin-Rockwell Corp., Jamestown, N. Y.	78553	Tinnerman Products, Inc., Cleveland, Ohio	97966	CBS Electronics Div. of Columbia Broadcast- ing Systems, Danvers, Mass.
40931	Honeywell Inc., Minneapolis, Minn. 55408	79089	RCA, Commercial Receiving Tube and Semi- conductor Div., Harrison, N. J.	98291	Sealectro Corp., Mamaroneck, N. Y. 10544
42190	Muter Co., Chicago, Ill. 60638	79725	Wiremold Co., Hartford, Conn. 06110	98821	North Hills Electronics Inc., Glen Cove, N. Y.
42498	National Co. Inc., Melrose, Mass. 02176	79963	Zierick Mfg. Co., New Rochelle, N. Y.	99180	Transitron Electronics Corp., Melrose, Mass.
43991	Norma-Hoffman Bearings Corp., Stanford, Conn. 06904	80030	Prestole Fastener Div. Bishop and Babcock Corp., Toledo, Ohio	99378	Atlee Corp., Winchester, Mass. 01890
49671	RCA, New York, N. Y.	80048	Vickers Inc. Electric Prod. Div., St. Louis, Mo.	99800	Delevan Electronics Corp., E. Aurora, N. Y.
49956	Raytheon Mfg. Co., Waltham, Mass. 02154	80131	Electronic Industries Assoc., Washington, D.C.	83033	Meissner Mfg., Div. of Maguire Industries, Inc., Mount Carmel, Illinois
		80211	Motorola Inc., Franklin Park, Ill. 60131		LRC Electronics, Horseheads, New York
		80258	Standard Oil Co., Lafayette, Ind.		Sprague Products Co., N. Adams, Mass.
		80294	Bourns Inc., Riverside, Calif. 92506		
		80431	Air Filter Corp., Milwaukee, Wisc. 53218		

PARTS LIST

Ref. No.	Description	Part No.	Fed. Mfg. Code	Mfg. Part No.	Fed. Stock No.
CAPACITORS					
C201	Plastic, 0.022 μ F $\pm$ 5% 400 V	4860-7859	84411	663UW, 0.022 μ F $\pm$ 5%	
C202	Plastic, 0.47 μ F $\pm$ 10% 200 V	4860-8248	84411	663UW, 0.47 μ F $\pm$ 10%	
C901	Mica, 48.7 pF $\pm$ 1% $\pm$ 20 PPM	4600-0154	14655	5A, 48.7 pF $\pm$ 1%	
C902	Mica, 0.0048 μ F $\pm$ 1% $\pm$ 10 PPM	4560-0148	14655	1A, 0.00487 μ F $\pm$ 1%	
C903	Air, 6-100 pF	4380-0900	73035	APC-6-100 pF	
C904	Electrolytic, 10 μ F +100-10% 25 V	4450-3800	56289	30D106G025BB4M1	5910-952-8658
C905	Plastic, 0.0022 μ F $\pm$ 10% 400 V	4863-2229	56289	194P22294	
C906	Plastic, 0.0068 μ F $\pm$ 10% 400 V	4863-2689	56289	194P22294	
C907	Plastic, 0.22 μ F $\pm$ 10% 400 V	4863-3229	56289	194P22394	
RESISTORS					
R201	Wire-Wound, 632 k Ω $\pm$ 0.025%	6984-6004	24655	6984-6004	
R202	Film, 2 M Ω $\pm$ 1% 1/2 W	6450-4200	75042	CEC, 632 k Ω $\pm$ 0.025%	5905-539-0802
R203	Film, 1 M Ω $\pm$ 1% 1/8 W	6250-4100	75042	CEA, 1 M Ω $\pm$ 1%	5905-646-5678
R204	Potentiometer, composition 10 k Ω $\pm$ 20%	6040-0700	01121	FWC, 10 k Ω $\pm$ 20%	5905-549-2773
R205	Film, 51.1 Ω $\pm$ 1% 1/8 W	6250-9511	75042	CEA, 51.1 Ω $\pm$ 1%	5905-552-3477
R206	Wire-Wound, 70.22 k Ω $\pm$ 0.025% 1 W	6983-5008	24655	6983-5008	
R207	Composition, 68 M Ω $\pm$ 5% 1/2 W	6100-6685	01121	EB, 68 M Ω $\pm$ 5%	
R208	Film, 5 M Ω $\pm$ 1% 1/2 W	6450-4500	75042	MDC, 5 M Ω $\pm$ 1%	
R209	Film, 80.6 k Ω $\pm$ 1% 1/8 W	6250-2806	75042	CEA, 80.6 k Ω $\pm$ 1%	
R210	Film, 8.66 k Ω $\pm$ 1% 1/8 W	6250-1866	75042	CEA, 8.66 k Ω $\pm$ 1%	
R211	Film, 5.6 k Ω $\pm$ 1% 1/4 W	6350-1560	75042	CEB, 5.6 k Ω $\pm$ 1%	
R212	Film, 2.7 k Ω $\pm$ 1% 1/8 W	6250-1270	75042	CEA, 2.7 k Ω $\pm$ 1%	
R213	Composition, 16 M Ω $\pm$ 5% 1/2 W	6100-6165	01121	RC20GF186J	5905-279-2503
R214	Film, 6.65 M Ω $\pm$ 1% 1 W	6550-4665	75042	MEF, 6.65 M Ω $\pm$ 1%	5905-800-2815
R215	Film, 3.65 M Ω $\pm$ 1% 1/2 W	6450-4365	56289	420E, 3.65 M Ω $\pm$ 1%	
R216	Film, 237 k Ω $\pm$ 1% 1/8 W	6250-3237	75042	CEA, 237 k Ω $\pm$ 1%	5905-681-8761
R217	Film, 3.01 k Ω $\pm$ 1% 1/8 W	6250-1301	75042	CEA, 3.01 k Ω $\pm$ 1%	5905-702-5974
R218	Potentiometer, wire-wound 1 k Ω $\pm$ 10%	6051-2109	02660	2600-PC, 1 k Ω $\pm$ 10%	
R219	Film, 500 k Ω $\pm$ 1% 1/4 W	6350-3500	75042	CEB-T0, 500 k Ω $\pm$ 1%	
R220	Film, 40.2 k Ω $\pm$ 1% 1/8 W	6250-2402	75042	CEA, 40.2 k Ω $\pm$ 1%	5905-801-8119
R221	Potentiometer, composition 5 k Ω $\pm$ 10%	6040-0600	01121	FWC, 5 k Ω $\pm$ 10%	5905-034-5374
R222	Potentiometer, wire-wound 500 Ω $\pm$ 10%	6051-1509	02660	2600 PC, 500 Ω $\pm$ 10%	
R223	Film, 8.87 k Ω $\pm$ 1% 25 1/2 W	6193-1887	75042	MEC-T9, 8.8 k Ω $\pm$ 1%	
R224	Potentiometer, composition 1 M Ω $\pm$ 20%	6040-1500	01121	FWC, 1 M Ω $\pm$ 20%	
R225	Film, 8.66 M Ω $\pm$ 1% 1 W	6550-4866	75042	MDF, 8.66 M Ω $\pm$ 1%	
R226	Composition, 8.2 k Ω $\pm$ 5% 2 W	6120-2825	01121	RC42GF822J	5905-192-4504
R227	Film, 100 k Ω $\pm$ 1% 1/8 W	6250-3100	75042	CEA, 100 k Ω $\pm$ 1%	5905-577-6743
R228	Potentiometer, wire-wound 200 Ω $\pm$ 10%	6051-1209	96791	2600 PC, 200 Ω $\pm$ 10%	
R230	Film, 10 k Ω $\pm$ 1% 1/2 W	6450-2100	75042	CEC, 10 k Ω $\pm$ 1%	5905-542-8401
R231	Potentiometer, wire-wound 5 k Ω $\pm$ 10%	6051-2509	02660	2600-PC, 5 k Ω $\pm$ 10%	
R232	Wire-Wound, 4.65 k Ω $\pm$ 0.01% 1 W	6983-4004	24655	6983-4004	
R233	Film, 4.02 k Ω $\pm$ 1% 1/8 W	6250-1402	75042	CEA, 4.02 k Ω $\pm$ 1%	5905-702-7231
R234	Film, 100 k Ω $\pm$ 1% 1/8 W	6250-3100	75042	CEA, 100 k Ω $\pm$ 1%	5905-577-6743
R235	Film, 100 k Ω $\pm$ 1% 1/4 W	6350-3100	75042	CEB, 100 k Ω $\pm$ 1%	
R236	Wire-Wound, 11.36 k Ω $\pm$ 0.01% 1 W	6983-5003	24655	6983-5003	
R238	Film, 250 k Ω $\pm$ 1% 1/4 W	6350-3250	75042	CEB, 250 k Ω $\pm$ 1%	
R239	Film, 619 k Ω $\pm$ 1% 1/8 W	6250-3619	75042	CEA, 619 k Ω $\pm$ 1%	5905-721-0523
R240	Composition, 15 k Ω $\pm$ 5% 1/2 W	6100-3155	01121	RC20GF153J	5905-279-2616
R241	Composition, 27 M Ω $\pm$ 5% 1/2 W	6100-6275	01121	EB, 27 M Ω $\pm$ 5%	
R901	Film, 10 k Ω $\pm$ 1% 1/8 W	6250-2100	75042	CEA, 10 k Ω $\pm$ 1%	5905-883-4847
R902	Composition, 10 k Ω $\pm$ 5% 1/2 W	6100-3105	01121	RC20GF103J	5905-185-8510
R903	Composition, 10 k Ω $\pm$ 5% 1/2 W	6100-3105	01121	RC20GF103J	5905-185-8510
R904	Composition, 11 k Ω $\pm$ 5% 1/2 W	6100-3115	01121	RC20GF113J	5905-279-2667
R905	Film, 10 k Ω $\pm$ 5% 1/2 W	6100-3105	01121	RC20GF103J	5905-185-8510
R906A	Potentiometer, wire-wound 250 Ω	6051-1010	24655	6051-1010	
R906B	1 k Ω				
MISCELLANEOUS					
CR201	DIODE, Type 1N2166A, 9.4 V $\pm$ 0.2 V 0.4 W	6083-1011	07595	1N2166A	
CR202 thru CR207	DIODE, Type 1N457	6082-1009	24446	1N4442	5961-929-9967
CR209	DIODE, Type 1N3253	6081-1001	79089	1N3253	5961-814-4251
J901	JACK	0938-3002	24655	0938-3002	
J902	JACK	0938-3002	24655	0938-3002	
J903	JACK	0938-3022	24655	0938-3002	
J904	JACK	1806-1000	24655	1806-1000	6625-050-6589
PL901	PLUG	4220-5295	02660	26-4100-24P	
PL902	PLUG	4220-5298	71785	26-4100-32P	
PL903	PLUG	1800-3550	24655	1800-3550	
SO901	SOCKET	4230-3301	24655	4230-3301	
S901	SWITCH	7890-3700	76854	Type F	
S902	SWITCH	7890-3710	76854	Type F	
S903	SWITCH	7890-3720	76854	Type F	
V901	TUBE	8390-0670	24455	NE-76	
V902	TUBE	8390-0670	24455	NE-76	
	Etched Circuit Assembly Complete	1820-2701	24655	1820-2701	
	Etched Circuit Assembly Complete	1820-2791	24655	1820-2791	
	Knob, bar	5500-5221	24655	5500-5221	
	Knob	5540-2500	24655	5540-2500	
	Monogram Tab	5580-0802	24655	5580-0802	

PARTS LIST

Ref. No.	Description	Part No.	Fed. Mfg. Code	Mfg. Part No.	Fed. Stock No.
CAPACITORS					
C1*	Part of 1800-3550	1800-2610	24655	1800-2610	
C101	Plastic, 0.001 μ F $\pm$ 10% 400 V	4863-2109	56289	194P10394	
C103	Plastic, 470 pF $\pm$ 10% 400 V	4863-1479	56289	194P47194	
C104	Ceramic, 1.0 μ F $\pm$ 20% 25 V	4400-2070	80183	5C13, 1.0 μ F $\pm$ 20%	
C105	Electrolytic, 33 μ F $\pm$ 20% 10 V	4450-5400	56289	150D336X0010B1	5910-823-1623
RESISTORS					
R1*	Part of 1800-3550 100 M Ω $\pm$ 5% 1/4 W				
R2*	Part of 1800-3550 100 M Ω $\pm$ 5% 1/4 W				
R101	Composition, 10 M Ω $\pm$ 5% 1/2 W	6100-6105	01121	RC20GF106J	5905-279-1865
R102	Composition, 100 k Ω $\pm$ 5% 1/2 W	6100-4105	01121	RC20GF104J	5905-195-6761
R103	Composition, 10 M Ω $\pm$ 5% 1/2 W	6100-6105	01121	RC20GF106J	5905-279-1865
R104	Composition, 47 k Ω $\pm$ 5% 1/2 W	6100-3475	01121	RC20GF473J	5905-254-9201
R105	Composition, 15 k Ω $\pm$ 5% 1/2 W	6100-3155	01121	RC20GF153J	5905-279-2616
R106	Composition, 47 k Ω $\pm$ 5% 1/2 W	6100-3475	01121	RC20GF473J	5905-254-9201
R107	Composition, 7.5 k Ω $\pm$ 5% 1/2 W	6100-2755	01121	RC20GF753J	5905-249-4195
R108	Composition, 4.7 k Ω $\pm$ 5% 1/2 W	6100-2475	01121	RC20GF472J	5905-279-3504
R109	Composition, 680 Ω $\pm$ 5% 1/2 W	6100-1685	01121	RC20GF681J	5905-195-6791
R111	Photocell	6740-2030	36462	GR367C	
R112	Photocell	6740-2030	36462	GR367C	
R113	Film, 1.96 M Ω $\pm$ 1% $\pm$ 25 PPM 1 W	6194-4196	75042	MEF-T, 1.96 M Ω $\pm$ 1%	
R114	Film, 1.96 M Ω $\pm$ 1% $\pm$ 25 PPM 1 W	6194-4196	75042	MEF-T9, 1.96 M Ω $\pm$ 1%	
R115	Film, 1.96 M Ω $\pm$ 1% $\pm$ 25 PPM 1 W	6194-4196	75042	MEF-T9, 1.96 M Ω $\pm$ 1%	
R116	Film, 2 M Ω $\pm$ 1% $\pm$ 25 PPM 1 W	6194-4200	75042	MEF-T9, 2 M Ω $\pm$ 1%	
R117	Film, 2 M Ω $\pm$ 1% $\pm$ 25 PPM 1 W	6194-4200	75042	MEF-T9, 2 M Ω $\pm$ 1%	
R118	Film, 98 k Ω $\pm$ 1% $\pm$ 25 PPM 1/2 W	6193-2980	75042	MEC-T9, 98 k Ω $\pm$ 1%	
R119	Potentiometer, wire-wound 5 k Ω $\pm$ 10%	6051-2509	02660	2600-PC, 5 k Ω $\pm$ 10%	
MISCELLANEOUS					
Q101	TRANSISTOR, Type 2N1305	8210-1305	96214	2N1305	5961-853-1079
Q102	TRANSISTOR, Type C6601	8210-1032	12498	C6601	
V101	TUBE, neon bulb A1C	8390-0320	24455	A1C	
V102	TUBE, neon bulb A1C	8390-0320	24455	A1C	
V1	TUBE Part of PL903				

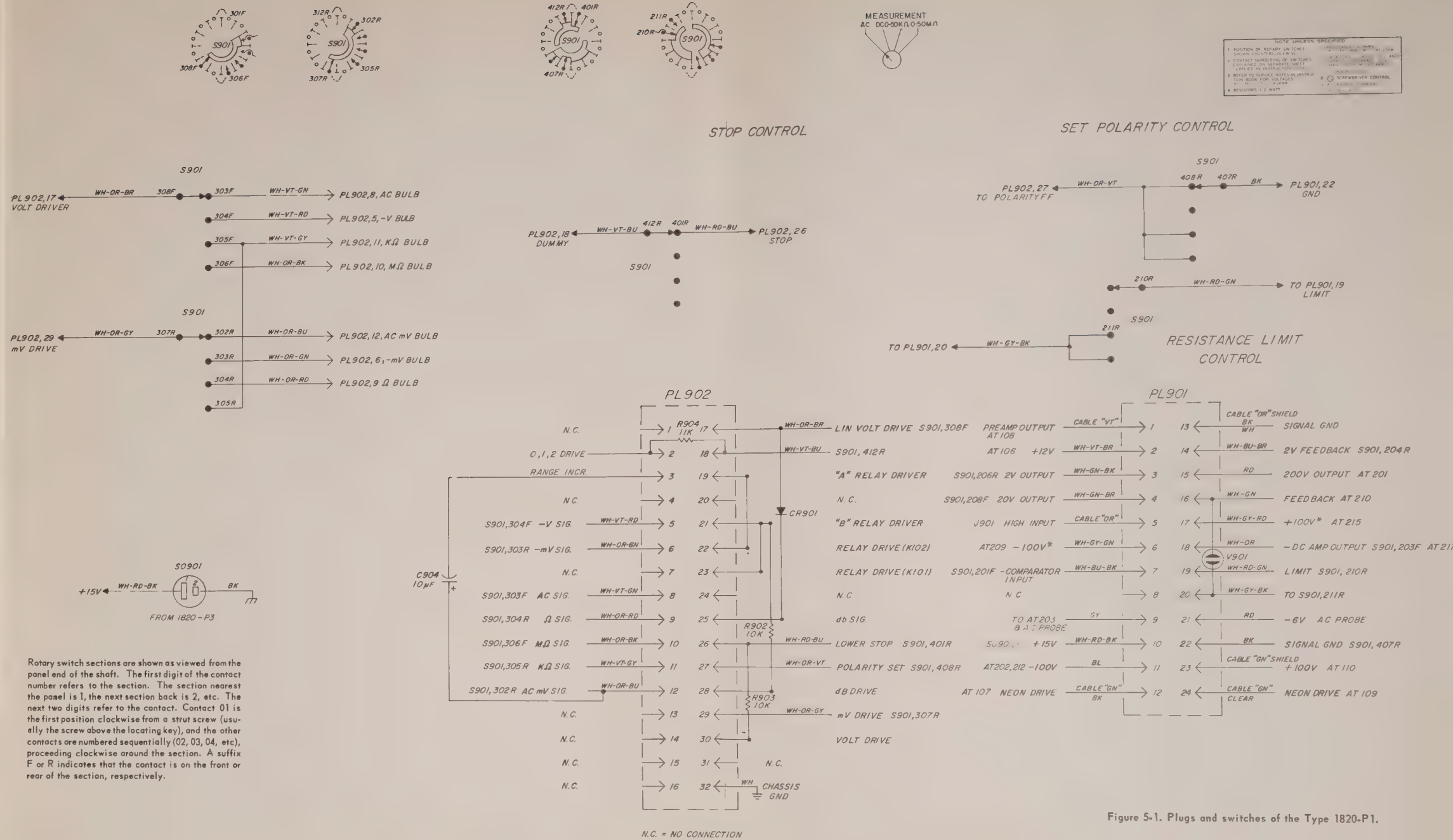


Table 5-1
Photochopper and Preamplifier Etched-Board Assembly
(P/N 1820-2701)

Anchor Terminals	Wire Color	Signal	Immediate Connection	Destination (Origin)	Anchor Terminal
101	wh	CHOPPER INPUT	S901, 111R	(Dc Input or Probe)	*
102	bk	FEEDBACK	AT107	(Ω -Adjust Resistors)	
103		CHOPPER INPUT			
104		PREAMP INPUT			
105	wh-gn-bu	FEEDBACK	R906B Tap	(9-V Floating Supply)	
106	wh-vt-br	+12-V BIAS	PL901, 2	(Main-Amplifier Bias)	(MF) 101
107	clear	NEON DRIVE	PL901, 12	(Neon Driver)	(MF) 115
108	vt	PREAMP OUTPUT	PL901, 1	Main-Amplifier Input	(MF) 102
109	clear	NEON DRIVE	PL901, 24	(Neon Driver)	(MF) 117
110	gn	+100-V BIAS	PL901, 23	(Main-Amplifier Bias)	(MF) 114
111	bk	GND			
112	wh-rd-br	PLUG-IN INPUT	S902, 109F	(Input Terminals)	*
113	wh-gy-br	DC ATTEN OUTPUT	S902, 104R	Time-Constant Filter	101*
116	bk	GND			
117	bk	GND			

*These connections are made via the associated switch. Refer to the diagram containing the anchor terminals involved for intermediate connectors.

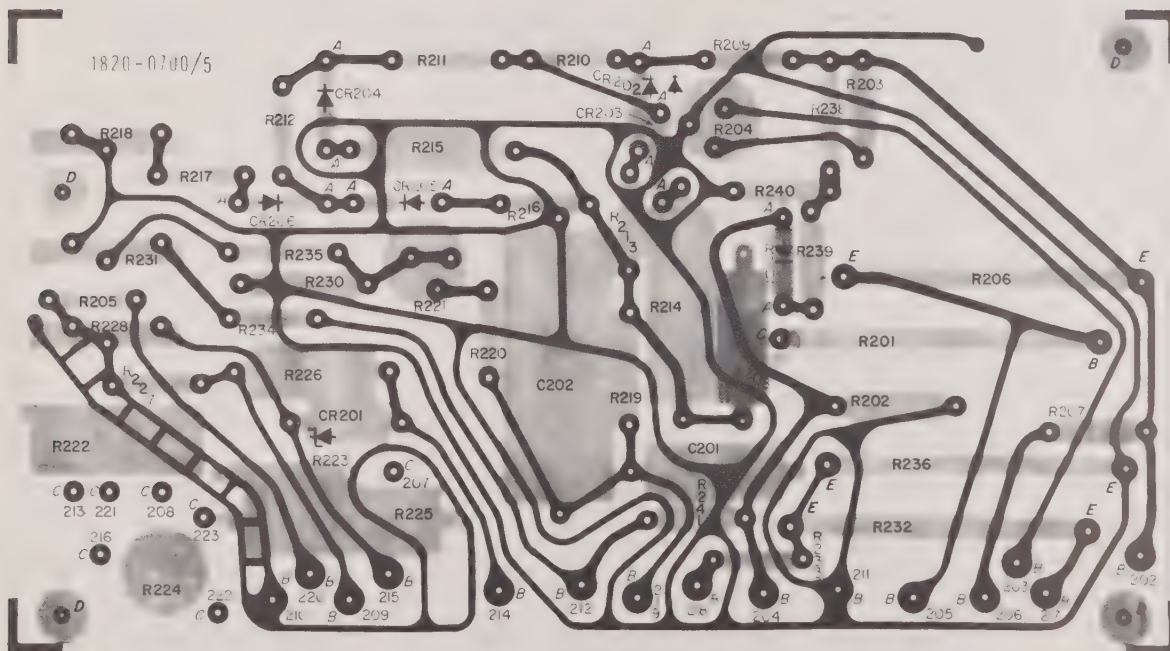


Figure 5-2a. Photo-chopper-and-Preamplifier Etched-Board Assembly (P/N 1820-2701).

NOTE: The number appearing on the foil side is not the part number.
The dot on the foil at the transistor socket indicates the collector lead.

Table 5-2
Compensation-Networks Etched-Board Assembly
(P/N 1820-2791)

Anchor Terminals	Wire Color	Signal	Immediate Connection	Destination (Origin)	Anchor Terminal
201	rd	200-V RANGE INPUT	PL901, 15	(Main-Amp Divider)	(MF) 107
202	bu	-100-V BIAS	PL901, 11	(Power Supply)	(MF) 514
203	gy	PROBE BIAS	PL901, 9	(R2 (Probe))	
204	wh-bk	20-V RANGE INPUT	S901, 207F	(Main-Amp Divider)	(MF) 108*
205	wh-br	20-V RANGE INPUT	S901, 209F	(Main-Amp Divider)	(MF) 108*
206	wh-bu	20-V RANGE INPUT	S901, 210F	(Main-Amp Divider)	(MF) 108*
207	bk	FEEDBACK	AT101		
208		kΩ RANGE ADJUST	AT221		
209	wh-gy-gn	-100-V BIAS	PL901, 6	(Power Supply)	(MF) 506
210	wh-gn	FEEDBACK	PL901, 16	(Main-Amp Output)	(MF) 105
211	bk	GND			
212	wh-bu	-100-V BIAS	AT110		
213	wh-rd	FEEDBACK	S901, 106R	(9-V Floating Supply)	214*
214	wh-gy	FEEDBACK	S901, 108F	Chopper or Ω-Range Adj	*
215	wh-gy-rd	+100-V BIAS	PL901, 17	(Power Supply)	(MF) 505
216	wh-vt	FEEDBACK	S901, 107R	(9-V Floating Supply)	214*
217	wh-or	DC AMP OUTPUT	PL901, 18	(Dc Amp Output)	(MF) 113
218	wh-ye	RMS MULT OUTPUT	S901, 202F	- Comparator	(MF) 202
219	wh-br-bk	2-V RANGE FEEDBACK	PL901, 14	(Main-Amp Output)	(MF) 109
220	bu	FEEDBACK	R906B (CW)		
221		kΩ-RANGE ADJUST	AT208		
222		MΩ-RANGE ADJUST	AT223		
223		MΩ-RANGE ADJUST	AT222		

*These connections are made via the associated switch. Refer to the diagram containing the anchor terminals involved for intermediate connectors.

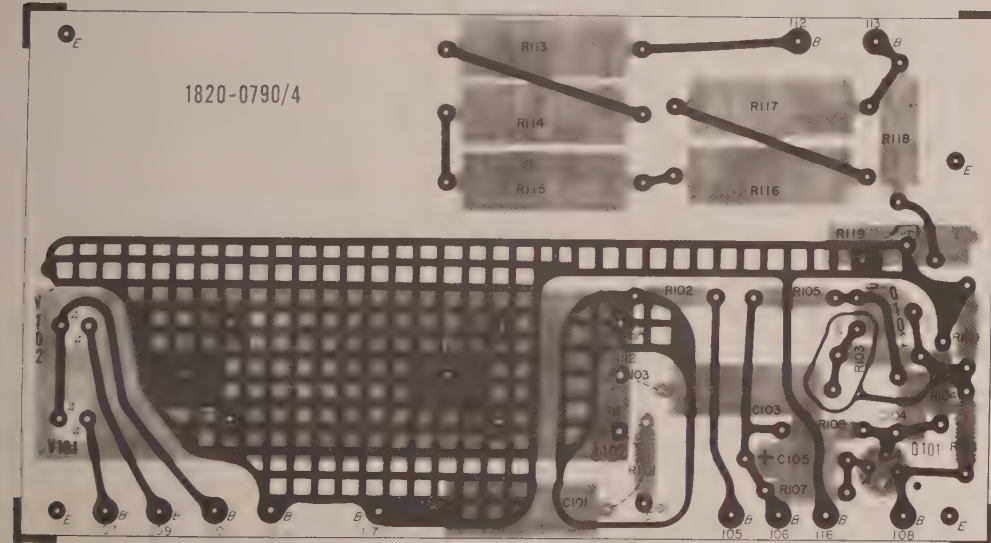


Figure 5-3. Compensation-Networks Etched-Board Assembly (P/N 1820-2791).

NOTE: The number appearing on the foil side is not the part number. The dot on the foil at the transistor socket indicates the collector lead.

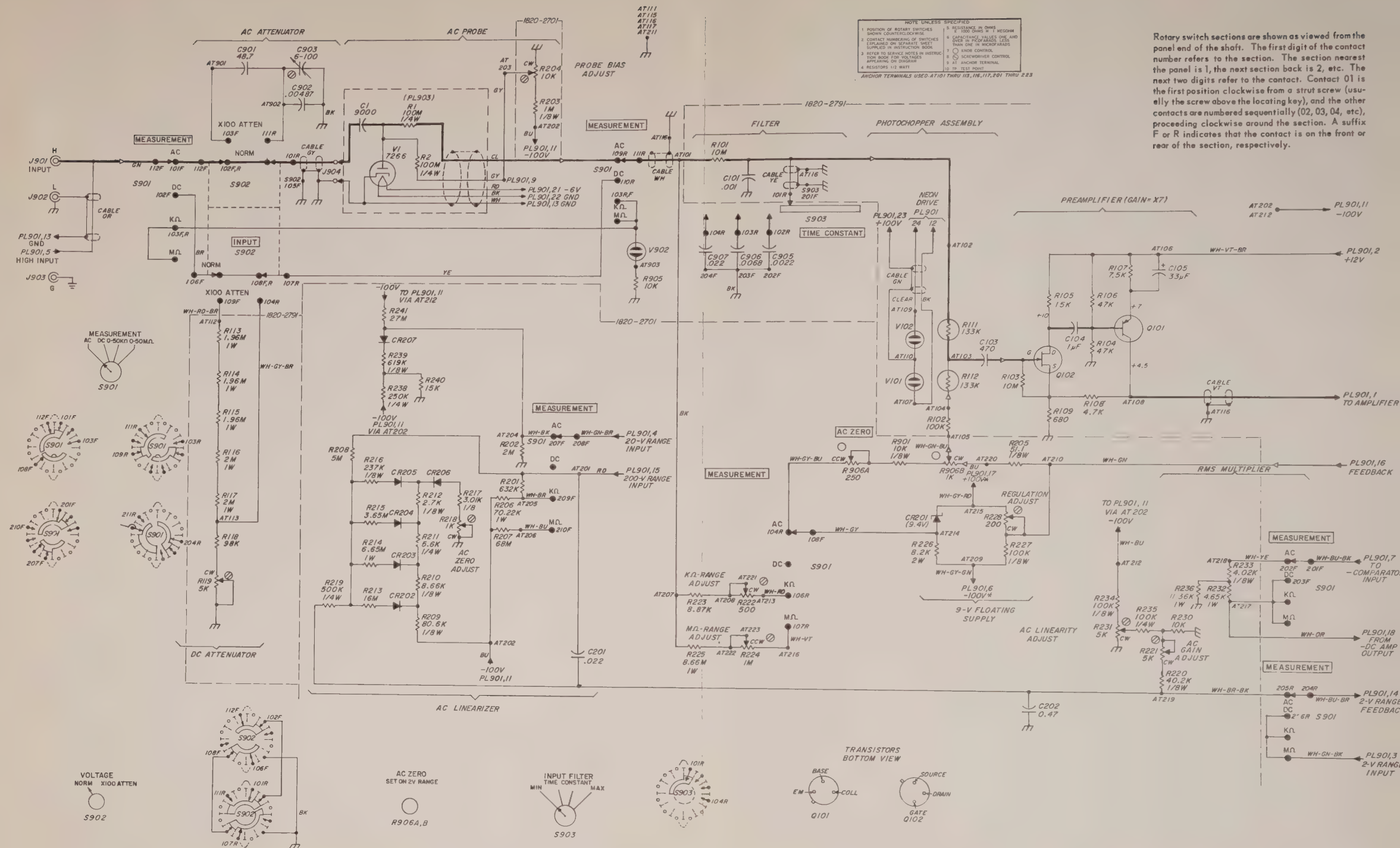


Figure 5-2b. Schematic diagram of the Type 1820-P1.

Type 1820-P2

AC/DC MILLIVOLTMETER

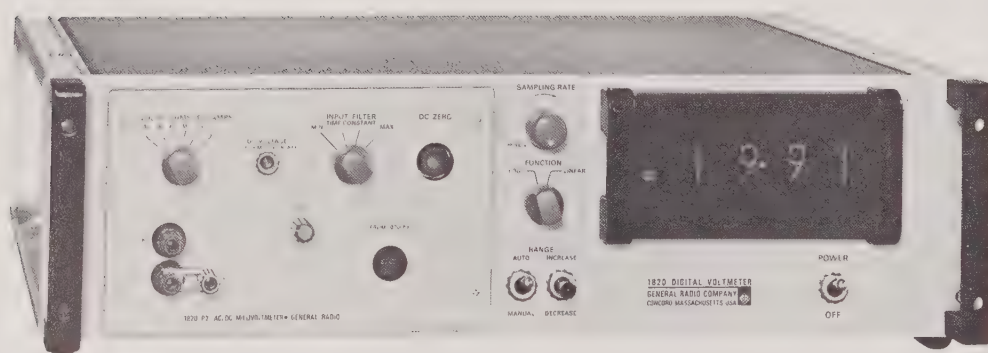
P/N 1820-9602

(Used only in the Type 1820 Digital Voltmeter)

Contents

Section 1 — Introduction	1
Section 2 — Operating Procedure	3
Section 3 — Principles of Operation	7
Section 4 — Service and Maintenance	9
Section 5 — Parts Lists and Diagrams	15

Specifications



AC/DC VOLTAGE

Linear Ranges: 2.200 mV to 220.0 V full scale, 6 ranges. With switched $\times 100$ attenuator, 1000 V dc full scale max.

Log Ranges: 6 to 122 dB re 100 μ V in six ranges.

Accuracy: Dc, $\pm(0.1\%$ of full scale + 5 μ V). Ac, 50 Hz to 100 kHz, $\pm(0.2\%$ of reading + 0.1% of full scale + 10 μ V); 20 Hz to 2 MHz, $\pm(2\%$ of reading + 0.2% of full scale + 50 μ V).

Log Accuracy on Ac: 50 Hz to 100 kHz: $\pm(0.1$ dB + 10 μ V).
20 Hz to 2 MHz: $\pm(0.4$ dB + 50 μ V).

Input Impedance: Dc, $>10^9 \Omega$ all ranges.

Ac, 1 M Ω + 40 pF, all ranges.

Noise: 5 μ V at 3 σ .

Speed (dc, with filter on min): Approx 40 ms for a step of up to 10% of full scale; 70 ms for full-scale step; 200 ms per range (max 800 ms for 6 ranges) for greater-than-full-scale step.

Speed (ac, with filter on min, at 1 kHz): Approx 800 ms for full-scale step; 1 s per range (max 4 s for 6 ranges) for greater-than-full-scale step.

Input-Filter Time Constant: Dc volts, 2 ms to 0.1 s; ac, 200 ms to 1 s.

RESISTANCE

0-20 k Ω Range: 2.200 Ω to 22.00 k Ω in 5 decade ranges.

0-20 M Ω Range: 2.200 k Ω to 22.00 M Ω in 5 decade ranges.

Accuracy: 0-20 k Ω range, $\pm(0.1\%$ of full scale + 0.1% of reading + 5 m Ω); 0-20 M Ω range, $\pm(0.1\%$ of full scale + 0.4% of reading + 5 Ω).

CURRENT

Dc: 2.200 nA to 220.0 μ A full scale, in 6 ranges, (1 M Ω). 2.200 μ A to 2.200 mA full scale, in 4 ranges, (1 k Ω). Extendable with external shunts.

Accuracy: Microampere range, $\pm(0.1\%$ of full scale, +0.1% of reading + 5 nA); nanoampere range, $\pm(0.1\%$ of full scale + 0.1% of reading + 5 pA).

Ac: Measured with any Tektronix current probe; with type 6020 and termination, 1 mA corresponds to 1 mV or 0.1 mV.

Accuracy: $\pm(1\%$ of reading + 0.2% of full scale + 10 nA) at 100 kHz. For low-frequency limit, see probe specifications; high-frequency limit, 2 MHz.

Accessories Supplied: Adaptor, binding post to BNC.

Accessories Available: Tektronix current probe for ac measurements.

Introduction—Section 1

1.1 PURPOSE.	1
1.2 DESCRIPTION.	1
1.3 ACCESSORIES	1
1.4 CONTROLS AND CONNECTORS.	1

1.1 PURPOSE.

The Type 1820-P2 Ac/Dc Millivoltmeter is a high sensitivity plug-in unit for the Type 1820-A Digital Voltmeter. With it, ac and dc measurements can be made in full scale ranges from 2 mV to 200 V, and resistance and current measurements can be made, the latter in full-scale ranges from 2 nA to 2 mA. Digital readout is linear or logarithmic in six ranges. Input impedance is $10^8 \Omega$ or greater for dc measurements, $1 M\Omega$ for ac. The unit has a X100 dc attenuator that can be switched in for measurements from 200 to 1000 Vdc, a variable-time-constant input filter, and floatable input terminals.

1.2 DESCRIPTION.

The Type 1820-P2 comprises an input attenuator and filter, a constant-current source for resistance measurements, an ac amplifier section, a precision

average detector, a photochopper assembly, a dc amplifier, and a set of logic circuits that control the gain of the preamplifier according to ranging information received from the main instrument.

1.3 ACCESSORIES.

The accessories supplied with the Type 1820-P2 Ac/Dc Millivoltmeter are listed in Table 1-1.

An accessory current probe is required for ac current measurements. Recommended is the Tektronix P6020 Ac Current Probe with Passive Termination, part number 015-0066-00, or the Tektronix P6019 Ac Current Probe with Passive Termination, part number 015-0065-00.

1.4 CONTROLS AND CONNECTORS.

The controls and connectors of the Type 1820-P2 are listed in Table 1-2.

TABLE 1-1
ACCESSORIES SUPPLIED

Quantity	Description	Part Number
1	Instruction manual	1820-0120
1	GR 274-QBJ Adaptor, double plug to BNC plug	0274-9884
1	Fuse, 1/10 A, Fast-Blo	5330-3100

TABLE 1-2
CONTROLS AND CONNECTORS

<i>Ref. No. (Figure 1-1)</i>	<i>Name</i>	<i>Description</i>	<i>Function</i>
1	Measurement selector	6-position rotary switch	Determines whether instrument is to measure ac voltage (VOLTS AC), dc voltage (VOLTS DC), resistance (OHMS k Ω or M Ω), or dc current (DC AMPS nA or μ A).
2	DC VOLTAGE selector	2-position screwdriver operated switch	Determines attenuation of dc input voltage; no attenuation in the NORM position; X100 position (to be used only for dc input voltages greater than 220 V), which extends meter range to 1000 Vdc.
3	INPUT FILTER TIME CONSTANT selector	4-position rotary switch	Selects time constant for input filter, which attenuates input noise. Time constants are, approximately, 2 ms (MIN), 35 ms, 70 ms, and 100 ms (MAX).
4	DC ZERO adjustment	Thumb control, rotary	For setting dc zero on mV range with input terminals short circuited.
5	from 1820-P3	2-connector socket, Jones Part No. 5-302-AB	Supplies 15-V bias voltage to Type 1820-P3 Differential Adaptor.
6	Mounting rod	Threaded rod with knob	For mechanical connection to Type 1820-A.
7	Ground terminal,	Type 274 non-insulated binding post	For connection to chassis ground.
8,9	Input terminals, H-high (9) and L-low (8)	Type 274 insulated 3/4-inch spaced binding-post pair	For application of unknown voltage, current or resistance.
not shown	Plug-in unit plugs	24- and 32-connector plugs, Amphenol Nos. 26-4100-24P and -32P	For electrical connection to Type 1820-A. Refer to Figure 5-5 for a listing of pin functions.

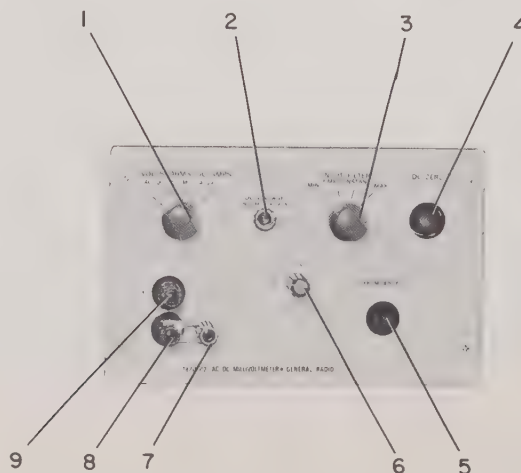


Figure 1-1. Controls and connectors of the Type 1820-P2.

Operating Procedures—Section 2

2.1 INSTALLATION	3
2.2 DC VOLTAGE SELECTOR	3
2.3 INPUT-FILTER TIME-CONSTANT SWITCH	3
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2.6 CURRENT MEASUREMENTS	4
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2.1 INSTALLATION.

Turn the POWER switch on the main frame OFF. Insert the plug-in unit into the main frame and press it in until the front panels are flush. Tighten the knurled screw (on the mounting rod) in the center of the plug-in to secure it to the main frame.

2.2 DC VOLTAGE SELECTOR.

The DC VOLTAGE selector is a screwdriver operated switch, which in the X100 position inserts an attenuator between the input terminals and the remaining non-ac circuits, i.e., the photochopper and dc amplifier, as shown in the block diagram of Figure 3-1.

Leave this switch in the NORM position, except when the input signal level exceeds 220 Vdc. When the switch is in the X100 position, the dvm will display 0.01 times the actual dc input.

CAUTION

Do not apply more than 1000V dc or 200V rms to the instrument.

The setting of the DC VOLTAGE selector has no effect on ac, resistance, or current measurements.

2.3 INPUT-FILTER TIME-CONSTANT SWITCH.

Set the INPUT-FILTER TIME-CONSTANT switch to MIN for resistance and ordinary dc and ac measurements.

If the input signal is especially noisy, increase the input-filter time constant one step at a time until the digital display stabilizes. The time constants are, from MIN to MAX, approximately 2 ms, 35 ms, 70 ms, and 0.1 s.

2.4 AC AND DC VOLTAGE MEASUREMENTS.

WARNING

Voltages up to 1000 volts can be measured with this instrument, and such voltages are extremely dangerous. Be sure to exercise considerable caution when making connections or when operating the voltmeter for any high-voltage measurements.

2.4.1 CONNECTIONS.

Connections to the digital voltmeter can be made using the binding posts on the front of the plug-in or those on the rear of the main frame (connections through the rear of the main frame require an additional internal jumper on the high binding post of the Type 1820-P2 — see Figure 2-1). A link is used to connect the low terminal to the metallic binding post, which is the cabinet and the third-wire ground connection. With the MEASUREMENT knob in the AC or DC position, the digital indicators will display the voltage at the high binding post with respect to that at the low. The low binding post is the low terminal in the sense that it has much greater capacitance to the case ground than has the high binding post.

2.4.2 UNGROUNDED OPERATION.

To use the voltmeter with neither INPUT terminal grounded, remove the link between the low and

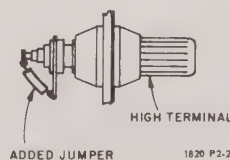


Figure 2-1. Detail showing added jumper on the high binding post.

the metal binding posts. The low terminal can then be connected to a circuit point that is as much as 400 Vdc from ground. A 1.0- μ F capacitor bypasses the low input terminal to the grounded cabinet at all times. Do not connect the low terminal to a voltage that has an ac component with respect to ground. Removal of the link is intended only for connection of the low terminal to a point whose voltage differs from ground by dc, not by ac. Keep the link connected between the metal and low binding posts for all ac measurements.

WARNING

Make sure the third wire of the Type 1820-A power cord is properly grounded; if it is not, the cabinet and the low binding post will be at the same ac potential with respect to ground, because of the 1.0- μ F capacitor.

CAUTION

Do not apply more than 200V rms or 280V peak to this instrument. Do not apply more than 1000V dc, and this only with the DC VOLTAGE switch at X100 ATT.

2.4.3 DC ZERO.

This adjustment affects measurements on the mV dc voltage range and on the lower resistance and current ranges. The zero should be set, therefore, before any series of measurements of small dc voltages, currents, or resistances. To set the DC ZERO:

- Set the Type 1820-A FUNCTION switch to LINEAR, RANGE to AUTO, and the 1820-P2 measurement selector to DC.
- Short the input terminals and adjust the DC ZERO control so that the display is 0000 and the polarity alternates regularly between + and -.

This adjustment has no effect on ac voltage measurements.

2.4.4 FREQUENCY RESPONSE.

The accuracy of ac voltage measurements made with the Type 1820-P2 is 0.2% (plus 0.1% of full scale plus 10 μ V) from 50 Hz to 100 kHz and 2% (plus 0.2% of full scale plus 50 μ V) from 20 Hz to 2 MHz. For measurements at frequencies higher than 2 MHz, use of the Type 1820-P1 Dc Multimeter/UHF Voltmeter with the Type 1820-A is recommended.

2.4.5 METER RESPONSE.

This plug-in unit is an average-detecting instrument for ac voltages. A constant is introduced into the display by the plug-in circuits so that the rms voltage of sinewave signals will be displayed. For signals of other waveforms, the displayed value will be the average voltage of the signal multiplied by 0.9.

2.5 RESISTANCE MEASUREMENTS.

To measure a resistance, set the DC ZERO (paragraph 2.4.3), connect the unknown across the high and low input terminals, and set the measurement switch to k Ω or M Ω . The k Ω ranges are 2 Ω , 20 Ω , 200 Ω , 2 k Ω , and 20 k Ω , full scale. The M Ω ranges are 2 k Ω , 20 k Ω , 200 k Ω , 2 M Ω , and 20 M Ω , full scale. Do not make

make low level resistance measurements through the rear terminals.

The Type 1820-P2 applies a 1-mA constant current to the unknown when the measurement switch is set to k Ω and a 1- μ A current for M Ω measurements.

2.6 CURRENT MEASUREMENTS.

2.6.1 DC CURRENT MEASUREMENTS.

To measure dc current (up to 2 mA) flowing through a component, set the DC ZERO (paragraph 2.4.3) and connect the high and low input terminals of the Type 1820-P2 in series with the component as shown in the example of Figure 2-2. The instrument measures the current by passing it through a 1-k Ω (for μ A

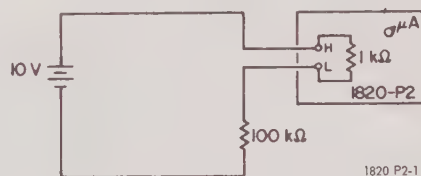


Figure 2-2. Dc current measurement with the Type 1820-P2.

measurements) or a 1-M Ω (for nA measurements) resistor and measuring the resulting voltage. The introduction of these resistors into the circuit being studied will, of course, have an effect on the current flow. The correspondence of the measured value to current flow in the unaltered circuit will depend on the magnitude of the series resistance introduced relative to the resistance in the circuit. In the example shown, the current flow in the circuit by itself would be 100 μ A. The measured current through the Type 1820 will be 99 μ A.

2.6.2 AC CURRENT MEASUREMENTS.

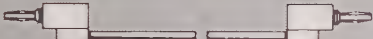
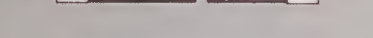
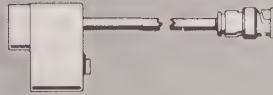
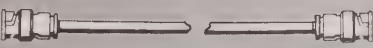
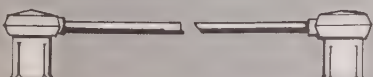
To measure ac current with the Type 1820-P2 a current probe, such as the Tektronix P6019 or P6020 AC Current Probe, is required. The Tektronix P6020 probe's small size makes it preferable for measurements in compact semiconductor circuits. To use this probe with the Type 1820-P2, plug the GR 274-QBJ into the input terminals (H and L), plug the Tektronix P6020 Passive Termination into the GR 274-QBJ, and connect the current-probe cable to the termination. Measure ac current as follows: open the spring-loaded slide on the probe, place the conductor (up to 0.100 inch diameter) in the probe slot, and release the slide. Set the switch on the P6020 termination to 10 mA/mV (for a low-frequency 3-dB cutoff at 935 Hz), and the Type 1820-P2 measurement switch to AC. The Type 1820 will display 100 μ V for each mA of ac current.

2.7 DISPLAY.

The Type 1820 will display the measured quantity with its polarity, the unit of measurement (V, mV, μ A, nA, k Ω , M Ω , or dB), and decimal-point location. This information (except scale and range) will also be available in BCD form at the DATA OUTPUT socket at the rear of the main frame. For information regarding the possible display modes, LOG, LINEAR, AUTO, etc., refer to the Type 1820-A instruction manual.

TABLE 1 - 1

AVAILABLE PATCH CORDS AND ADAPTORS

	TYPE NO.	DESCRIPTION	CATALOG NO.
	274-NQ	Double-plug patch cord, in-line cord, 36" long	0274-9860
	274-NQM	Double-plug patch cord, in-line cord, 24" long	0274-9896
	274-NQS	Double-plug patch cord, in-line cord, 12" long	0274-9861
	274-NP	Double-plug patch cord, right-angle cord, 36" long	0274-9880
	274-NPM	Double-plug patch cord, right-angle cord, 24" long	0274-9892
	274-NPS	Double-plug patch cord, right-angle cord, 12" long	0274-9852
	274-NL	Shielded double-plug patch cord, 36" long	0274-9883
	274-NLM	Shielded double-plug patch cord, 24" long	0274-9882
	274-NLS	Shielded double-plug patch cord, 12" long	0274-9862
	274-LLB	Single-plug patch cord, black, 36" long	0274-9468
	274-LLR	Single-plug patch cord, red, 36" long	0274-9492
	274-LMB	Single-plug patch cord, black, 24" long	0274-9847
	274-LMR	Single-plug patch cord, red, 24" long	0274-9848
	274-LSB	Single-plug patch cord, black, 12" long	0274-9849
	274-LSR	Single-plug patch cord, red, 12" long	0274-9850
	1560-P95	Adaptor cable, double-plug to telephone plug, 36"	1560-9695
	874-R34	Coaxial patch cord, double plug to GR874, 36" long	0874-9692
	874-R33	Coaxial patch cord, two plugs to GR874, 36" long	0874-9690
	274-QBJ	Adaptor, shielded double plug to BNC jack	0274-9884
	776-A	Patch cord, shielded double plug to BNC plug, 36" long	0776-9701
	776-B	Patch cord, GR874 (right-angle) to BNC plug, 36" long	0776-9702
	776-C	Patch cord, BNC plug to BNC plug, 36" long	0776-9703
	776-D	GR874 to GR874, both right-angle, 36" long	0776-9704

Principles of Operation—Section 3

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3.3 AC CIRCUITS.	8

3.1 GENERAL.

Figure 3-1 is a block diagram of the ac/dc millivoltmeter. The heart of the instrument is the dc amplifier and photochopper. All signals are applied to these and to the input filter, the dc signals by way of the dc attenuator, the ac signals by way of the ac amplifier and average detector. Voltages generated by current passing through the unknown resistor or

the reference resistor in the current-measuring circuits are applied directly to the photochopper. The output of the instrument is a chopped, amplified signal, the level of which is proportionate to the input signal, the amount of voltage feedback from the main amplifier and the BCD range signals from the Type 1820-A. For dc voltage measurements the loop gain of the main-frame/plug-in combination is constant on all ranges but the most sensitive, where it is 20 dB less.

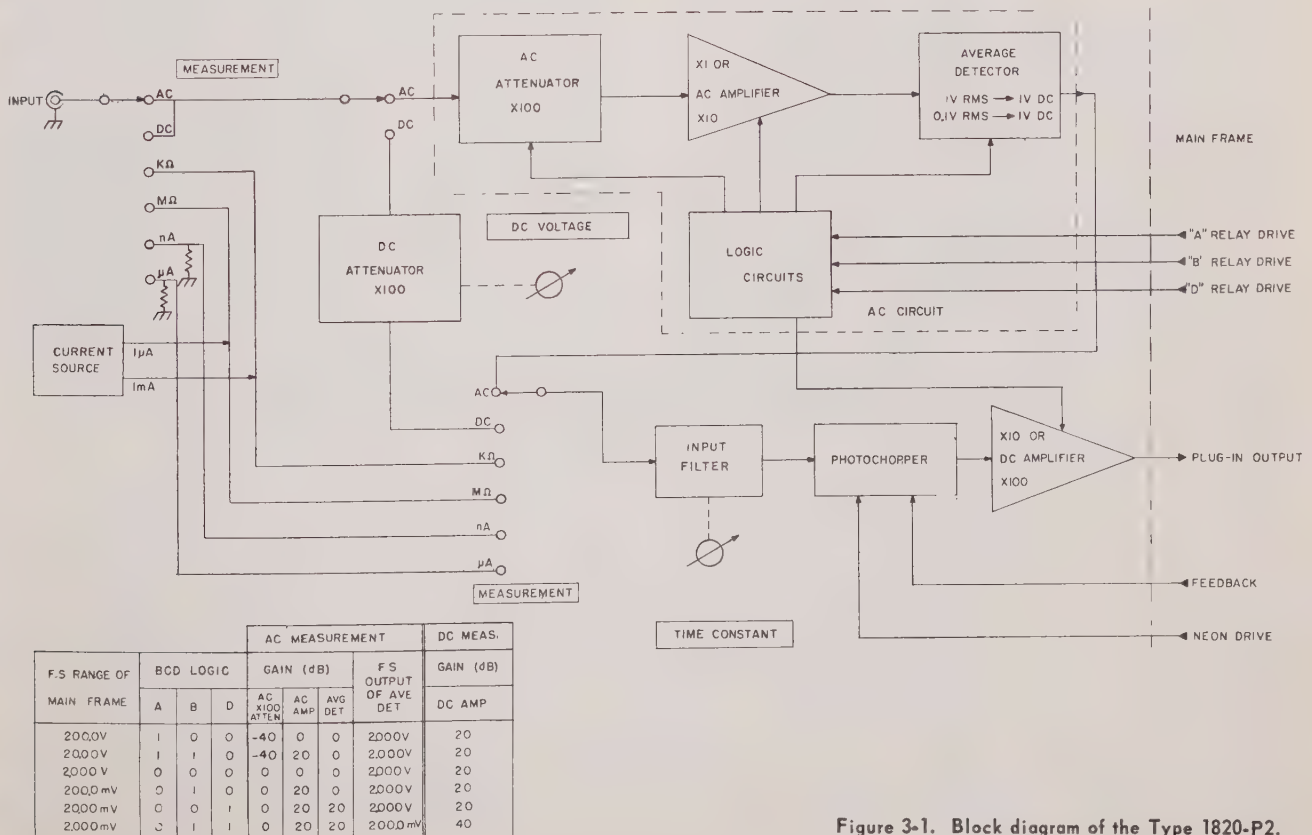


Figure 3-1. Block diagram of the Type 1820-P2.

3.2 INPUT AND DC CIRCUITS.

3.2.1 RESISTANCE-MEASUREMENT CIRCUIT.

Depending on the setting of the measurement switch, Q117 sends a constant current through the unknown resistance of 1 mA ($k\Omega$) or 1 μ A. The resistance from the front binding posts to the measuring circuit is compensated for by adjustment during calibration of R156 and R158.

3.2.2 DC CURRENT MEASUREMENT.

Dc currents are converted to dc voltage simply by being passed through R905 and R904, reference resistors connected across the input terminals by the measurement switch.

3.2.3 INPUT FILTER.

A selectable-time-constant RC input filter precedes the photochopper. In addition to filtering out unwanted signals, the resistive component of the filter, R301, acts as a protection against preamplifier overload. The capacitance of the filter is determined by the setting of S903, the INPUT FILTER TIME CONSTANT selector.

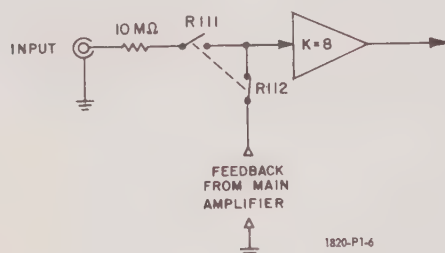


Figure 3-2. Equivalent circuit of the photochopper.

3.2.4 PHOTOCHOPPER.

The photochopper is a series-shunt combination (see Figure 3-2) with the input signal applied to the series element and the feedback from the main amplifier applied to the shunt element. The resistance of the photo resistors is alternately reduced by the application of light to their surfaces from two neon bulbs through a light-pipe assembly. The bulbs are driven by an oscillator in the main frame. Under normal operating conditions, the photochopper ef-

iciency, at a frequency of 300 Hz, is 70 to 90% (peak-to-peak ac output to dc input).

3.2.5 DC AMPLIFIER AND ATTENUATOR.

The dc attenuator (Figure 5-1) is a resistive divider switched into the photochopper input circuit by S902, the DC VOLTAGE selector. The dc amplifier consists of Q201, which operates at very low collector-current levels for high input impedance and low noise, and Q202 and Q203. The gain of this amplifier is 10 on the top four voltmeter ranges and 100 on the two lowest ranges. This gain is controlled by relay K201, which is operated by the "D" logic signal from the main amplifier. This signal also controls K202, which applies an amount of feedback to the main amplifier through R225 when the voltmeter is on its two lowest ranges.

3.3 AC CIRCUITS.

The ac circuits (Figure 5-3) begin with F101, a 1/10 -A fast-blow fuse, which protects the circuits from overload in case a voltage greater than 2.0 V is applied with the RANGE switch set to MANUAL or if any 200-V or greater signal is applied.

The operation of the ac-voltage-measuring circuits is as follows: Relays K101 and K102 will activate the X100 ac capacitive attenuator if the input signal is greater than 2.2 V. Otherwise the signal is applied directly to the input amplifier Q101 and Q103. The gain of this amplifier is 10 or 100 and is controlled by relays K104 and K105. The input impedance of this amplifier, achieved by bootstrapping with C105, is about 10 M Ω . To stabilize the input amplifier, R134 is added to the amplifier circuit by K103 when the ac amplifier is in the X1 gain state.

The precision rectifier is a half-wave type made up of transistors Q104 through Q107 and diodes CR107 and CR108. Transistor Q107 plays no active part in the circuit, except to increase the impedance at the collector of Q106 by bootstrapping. R131 and C119 act as a simple one-pole filter for the rectifier. The gain of the rectifier is such that 1 V rms will produce 1 or 10 Vdc, depending on the status of relays K108 and K109.

K107 inserts R105 and C121 when the rectifier is in the high gain state to correct for a rising low-frequency amplifier response. K110 corrects the low-frequency gain of the input amplifier when it is in the X10 gain state.

Service and Maintenance—Section 4

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4.4 ACCESS TO COMPONENTS	12
4.5 CALIBRATION PROCEDURE	12
4.6 TROUBLE ANALYSIS	14

4.1 WARRANTY.

We warrant that each new instrument manufactured and sold by us is free from defects in material and workmanship and that, properly used, it will perform in full accordance with applicable specifications for a period of two years after original shipment. Any instrument or component that is found within the two-year period not to meet these standards after examination by our factory, District Office, or authorized repair agency personnel, will be repaired or, at our option, replaced without charge, except for tubes or batteries that have given normal service.

4.2 SERVICE.

The two-year warranty stated above attests the quality of materials and workmanship in our products. When difficulties do occur, our service engineers will assist in any way possible. If the difficulty cannot be eliminated by use of the following service instructions, please write or phone our Service Department (see condensed operating instructions), giving full information of the trouble and of steps taken to remedy it. Be sure to mention the serial and type numbers of the instrument.

Before returning an instrument to General Radio for service, please write to our Service Department or nearest District Office, requesting a "Returned Material Tag." Use of this tag will ensure proper handling and identification. For instruments not covered by the warranty, a purchase order should be forwarded to avoid unnecessary delay.

4.3 MINIMUM PERFORMANCE STANDARDS.

4.3.1 GENERAL.

The procedures outlined in the following paragraphs provide a means of testing the accuracy of all the measurements performed by the Type 1820 Digital Voltmeter with the Type 1820-P2 Ac/Dc Millivoltmeter plug-in unit. The results of these tests depend on the calibration of the Type 1820-A main frame as well as that of the plug-in. If recalibration is found to be necessary, refer first to the procedure for the Type 1820-A in the Service and Maintenance section of that manual, then to paragraph 4.5 of this section. For a quick operational check, rather than an accuracy test, refer to paragraph 3.2 in the Type 1820-A instruction manual section.

TABLE 4-1
MINIMUM-PERFORMANCE TEST EQUIPMENT

<i>Device</i>	<i>Necessary Specifications</i>	<i>Recommended Type</i>
Digital voltmeter Main Frame	No substitution.	GR 1820-A Digital Voltmeter
Metered autotrans- former	Variable 0 to 125 V rms with wattmeter.	GR W5MT3W Metered Variac® autotransformer
Variable dc reference-volt- age source	±20 mV to ±200 V, ±0.05% accuracy.	Fluke Precision Voltage Calibrator Model 332A
Variable ac reference-volt- age source	20 mV to 100 V rms ±0.2% accuracy.	Ballantine Model 421A DC/AC Precision Calibrator
Precision decade resistor	±0.1% accuracy, 10Ω to 10 MΩ	GR 1433-H Decade Resistor
Oscilloscope (optional)	DC-coupled, medium bandwidth, single trace.	Tektronix Model 531 Oscilloscope with a Type K Plug-In Unit

TABLE 4-2
DC ACCURACY CHECK

<i>Set Reference</i>	<i>Display Limits - LINEAR</i>	<i>Display Limits - LOG</i>
+1.000 mV	+0.993 to +1.007 mV	NO LOG FUNCTION FOR +V
+10.00 mV	+9.97 to +10.03 mV	
+0.100 V	+99.8 to +100.2 mV	
+1.000 V	+0.998 to +1.002 V	
+10.00 V	+9.98 to +10.02 V	
+100.0 V	+99.8 to +100.2 V	
-1.000 mV	-0.993 to -1.007 mV	19.91 - 20.09 dB
-10.00 mV	-9.97 to -10.03 mV	39.94 - 40.06 dB
-0.100 V	-99.8 to -100.2 mV	59.95 - 60.05 dB
-1.000 V	-0.998 to -1.002 V	19.95 - 20.05 (+60) dB
-10.00 V	-9.98 to -10.02 V	39.95 - 40.05 (+60) dB
-100.0 V	-99.8 to -100.2 V	59.95 - 60.05 (+60) dB

4.3.2 EQUIPMENT REQUIRED.

The equipment required to test the Type 1820-P2 Ac/Dc Millivoltmeter against its published specifications is listed in Table 4-1.

4.3.3 POWER CONSUMPTION.

To determine that the Type 1820-A with the Type 1820-P2 consumes the nominal amount of power, use the following procedure.

a. Connect the digital voltmeter to a source of ac power via the metered Variac® Autotransformer and throw the POWER switch on.

b. Bring the Variac voltage up to the nominal value of the voltage range set by the Type 1820 line switch (e.g., 115 V). The power consumed should be 40 W (nominal), as indicated by the Variac meter.

4.3.4 DC VOLTS.

The following procedure checks the accuracy of the dc voltage measurements made with the Type 1820-A/1820-P2 combination.

a. Set the Type 1820 controls as follows:

POWER	on
RANGE	AUTO
SAMPLING RATE	center
FUNCTION	LINEAR

Measurement
DC VOLTAGE

DC
NORM

b. Set the dc reference-source voltage to +100.0 V and connect it to the Type 1820-P2 input terminals.

c. Measure the reference voltages shown in Table 4-2 to be within the limits (LINEAR) indicated.

d. Set the DC VOLTAGE switch to X100 ATT and the reference voltage to -200.0 V. The display should be within -1.998 V to -2.002 V in the LIN mode (25.97 dB to 26.07 dB in the LOG mode).

e. Set the FUNCTION switch to LOG and the DC VOLTAGE switch to NORM. Measure the negative dc reference levels given in Table 4-2 to within the display limits (LOG) shown.

4.3.5 AC VOLTS.

The following procedure checks the accuracy of ac voltage measurements made with the Type 1820-A/1820-P2 combination.

a. Set the Type 1820 controls as in paragraph 4.3.3 step a, except set the measurement switch to AC.

b. Set the ac reference-source voltage to 1.000 V rms at a frequency of 1 kHz and connect it to the Type 1820-P2 input.

c. Measure the reference voltages shown in Table 4-3 to be within indicated limits.

TABLE 4-3
AC ACCURACY CHECK

<i>Set Reference</i>	<i>Display Limits - LINEAR</i>	<i>Display Limits - LOG</i>
1 kHz	1.000 mV	19.81 - 20.19 dB
	10.00 mV	39.89 - 40.11 dB
	100.0 mV	59.90 - 60.10 dB
	1.000 V	19.90 - 20.10 (+60) dB
	10.00 V	39.90 - 40.10 (+60) dB
	100.0 V	59.90 - 60.10 (+60) dB
1 MHz	1.000 mV	19.20 - 20.80 dB
	100.0 mV	59.59 - 60.41 dB
	1.000 V	19.60 - 20.40 (+60) dB
	100.0 V	59.60 - 60.40 (+60) dB

TABLE 4-4
RESISTANCE ACCURACY CHECK

<i>Standard Resistance</i>	<i>Display Limits (kΩ Range)</i>	<i>Display Limits (MΩ Range)</i>
10 Ω	009.6 to 010.4 Ω*	- - - - -
1 kΩ	0.997 to 1.003 kΩ	- - - - -
10 kΩ	0.997 to 10.03 kΩ	0.009 to 0.010 MΩ*
1 MΩ	- - - - -	0.995 to 1.005 MΩ
10 MΩ	- - - - -	09.95 to 10.05 MΩ

*After DC ZERO has been adjusted.

d. Set the ac reference-source frequency to 1 MHz and measure the reference voltages shown in Table 4-3 to be within indicated limits.

e. Set the FUNCTION switch to LOG and the reference-source frequency to 1 kHz. Measure the voltage levels in Table 4-3 to be within indicated limits.

4.3.6 RESISTANCE.

The following procedure tests the accuracy of resistance measurements made by the Type 1820-A with the Type 1820-P2.

a. Set the controls as they were in paragraph 4.3.4 step a, except set the measurement switch to kΩ.

b. Connect in succession each of the resistors listed in Table 4-4 to the input terminals of the Type 1820-P2. The resistance values measured should be within the limits given in the kΩ-Range column of the table.

c. Set the measurement switch to MΩ and measure the resistance given in Table 4-4 to be within the limits listed in the MΩ-Range column.

4.3.7 DC CURRENT.

The following procedure tests the accuracy of dc current measurements made by the Type 1820-P2.

a. Set the controls as they were in paragraph 4.3.4 step a, except set the measurement switch to μA.

b. Connect one end of the 1-kΩ precision resistor to the high input terminal of the Type 1820-P2. Connect the dc reference-voltage source to the other side of the 1-kΩ resistor and the low input terminal.

c. Set the reference voltage to 200 mV. The voltmeter should display between 99.5 and 100.5 μA.

d. Set the measurement switch to nA and replace the 1-kΩ resistor with 1-MΩ reference resistor.

e. Set the reference voltage to 200 mV. The voltmeter should display between 99.5 and 100.5 nA.

4.3.8 SAMPLING RATE.

This procedure is an optional check on the existence of the print command pulse and on the effectiveness of the SAMPLING RATE control.

a. Set the Type 1820 controls as they were in paragraph 4.3.4 step a, except set the SAMPLING RATE control fully clockwise. Apply a stable dc voltage to the Type 1820-P2 input.

b. Set the oscilloscope controls as follows:

Triggering Mode	Automatic
Sync Mode	Internal
Input Coupling	Dc
Horizontal Sensitivity	10 ms/div
Vertical Sensitivity	5 V/div

c. Connect the oscilloscope probe to pin A2 of the DATA OUTPUT socket and the oscilloscope ground to the low input terminal of the Type 1820-P2. The display shown in Figure 4-1 should appear. The pulse period (*) should be about 33 ms ±20%.

d. Rotate the SAMPLING RATE control slowly clockwise and note that the time separation (*) between the 15-ms-10-V pulses increases to about 2 seconds.

4.4 ACCESS TO COMPONENTS.

To obtain access to the components of the Type 1820-P2 while it is in operation, remove the cover of the Type 1820 Digital Voltmeter main frame according to the directions given in Section 2 of its instruction manual. Figure 4-2 shows the location of anchor terminals, test points, and adjustable components.

4.5 CALIBRATION PROCEDURE.

4.5.1 EQUIPMENT REQUIRED.

The equipment required to calibrate the Type 1820-P2 is listed in Table 4-5.

4.5.2 GENERAL PROCEDURE.

If the Type 1820-A (main frame) has been calibrated, the adjustments on the plug-in can be made. Use the following procedure (and Figure 4-2) to adjust the Type 1820-P2.

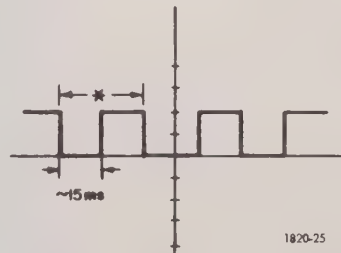


Figure 4-1. The print-command pulse.

TABLE 4-5
EQUIPMENT REQUIRED FOR CALIBRATION

<i>Device</i>	<i>Necessary Specifications</i>	<i>Recommended Type</i>
Digital-voltmeter main frame	No substitutions.	GR 1820 Digital Voltmeter
Reference-voltage supply	Stable dc source, adjustable to produce + and -200.00 V $\pm 0.05\%$	Fluke Precision Voltage Calibrator Model 332A
Dc voltmeter	Accurate to $\pm 0.01\%$	Fluke Model 881A DC Differential Voltmeter
100-k Ω decade divider	$\pm 0.015\%$ accuracy.	GR 1455-AH Decade Voltage Divider
Precision resistor	1-k Ω and 1-M Ω resistance, $\pm 0.02\%$	GR 1440-9631 and -9661 Standards
Sinewave oscillator	Capable of producing a 0.2-V, 20.0-V, 2.0-V, and a 20.0-mV, output at 1 kHz and a 2-V output at 100 kHz and 1 MHz.	GR 1308 Audio Oscillator and Power Amplifier
Patch cords (3)	Double-plug to double-plug	GR 274 NPM Double-Plug Patch Cord
Ac reference - voltage source	100-V, 1 kHz, < 0.05% distortion	GR 1311 Audio Oscillator
Precision transformer	- - - - -	GR 1493 Precision Decade Transformer
Ac VTVM	$\leq 0.05\%$ accuracy	Fluke model 913A
Oscillator	20 Hz to 2 MHz, 2 V	GR 1310 Oscillator
Transfer Standard	- - - - -	Ballantine model 393 HF Transfer Voltmeter with 2-V probe.
Tee	- - - - -	GR 874-T Tee
Cable	- - - - -	GR 874-R34 Patch Cord
Attenuator (4 required)	20 $\pm$ 0.30 dB	GR 874-G20L Fixed Attenuator
Adaptor	From GR874-to-GR 938 connectors	GR 777-Q3 Adaptor

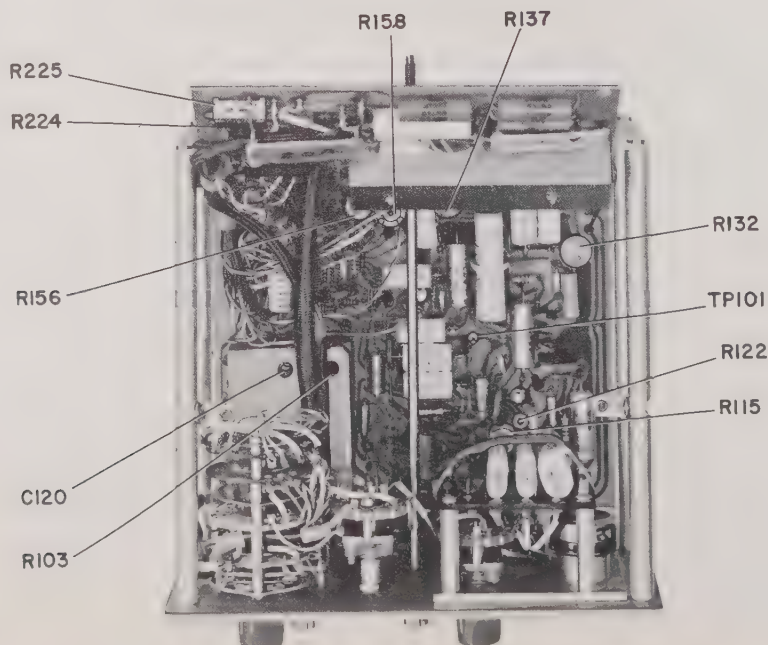


Figure 4-2. Interior view showing test points and secondary controls.

DC VOLTAGE

a. Connect the Type 1820-A with a Type 1820-P2 inserted to a power line and set the following controls:

POWER	on
FUNCTION	LINEAR
RANGE	AUTO
SAMPLING RATE	centered
Measurement	DC
DC VOLTAGE	NORM

b. Short the Type 1820-P2 input terminals and adjust the DC ZERO control for a display of 0.000 mV.

c. Obtain a reference voltage of +20.00 mV dc from the standard source and decade box. Apply this voltage to the input.

d. Adjust R225 for a correct display.

e. Set the DC VOLTAGE switch to X100 ATT. With the input shorted set the DC ZERO.

f. Apply to the input 200.0 Vdc and adjust R224 for a readout of +2.000 V.

b. High-Frequency Calibration and Low-Frequency Checks.

Connect the test set-up shown in Figure 4-3; use only a short length of coaxial cable between the Type 1310 and the Type 874-T.

Set the oscillator frequency to 1 kHz and adjust the output for an indication of 2.000 V ± 1 count on the Type 1820-A. Adjust the Transfer Standard controls for a null, as indicated by its galvanometer. Set the oscillator to 2 MHz and adjust the output for a null (on the Transfer Standard). Adjust R122 in the Type 1820-P2 for an indication of 2.000 V ± 44 counts.

NOTE

R122 also affects the high frequency end of the other ranges and may need readjustment later.

Repeat this procedure for the other ranges by using the following table.

AC VOLTAGE

NOTE

The sweep adjustments (-sweep) in the Type 1820-A must be made before ac calibration of the Type 1820-P2 is attempted.

a. 1-kHz calibration.

Apply 100 V rms at 1 kHz from the Type 1311 Oscillator to the input of the Type 1493 Transformer. Monitor this voltage with the Fluke AC VTVM and hold it within $\pm 0.05\%$ for all the following checks:

Type 1493 Output	Type 1820 Range (F.S.)	Type 1820-P2 Adjustment	Type 1820-A Indication
2.000 V	2 V	R137	2.000 ± 2 counts
200.0 mV	2 V	- - -	0.200 ± 2 counts
200.0 mV	200 mV	R115	200.0 ± 2 counts
20.00 mV	200 mV	- - -	020.0 ± 2 counts
20.00 mV	20 mV	R132	20.00 ± 3 counts
2.000 mV	20 mV	- - -	02.00 ± 3 counts
2.000 mV	2 mV	- - -	2.000 ± 16 counts

Repeat the above adjustments until all readings are within limits. Then continue:

20.00 V	20 V	R103	20.00 ± 2 counts
2.000 V	20 V	- - -	02.00 ± 2 counts
100.0 V	200 V	- - -	100.0 ± 2 counts
20.00 V	200 V	- - -	020.0 ± 2 counts

ADJUSTMENT NOTES

1. Reduce the oscillator output to zero before adding or subtracting pads to avoid damage to the Transfer Standard thermocouple.
2. Adjust the oscillator output for exact full-scale indication ± 1 count.
3. Null the Transfer Standard, using its own controls.
4. Adjust the oscillator output for a null on the Transfer Standard.

Since R122 controls the high-frequency response on several ranges, make adjustments only when close to the out-of-limits area, not for gross adjustments. R122 also has a slight effect on the 100-kHz response and at 10% of full scale (i.e., 0.200 V). There are no available adjustments for the 20- and 50-Hz responses.

In the following table, single numbers in the adjustment column (2, 3, or 4) refer to the adjustment notes above. The reference components (R122 and C120) are part of Type 1820-P2.

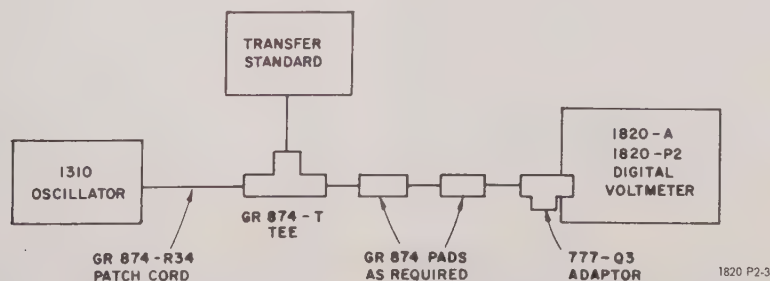


Figure 4-3. High-frequency test set-up.

Frequency	Attenuation (dB)	Full-Scale Range	Adjustments (in the order given)	Type 1820-A Indication
1 kHz	0	2 V	2, 3	2.000 ± 1
2 MHz	0	2 V	4, R122	2.000 ± 44
100 kHz	0	2 V	4, R122	2.000 ± 6
50 Hz	0	2 V	4	2.000 ± 6
20 Hz	0	2 V	4	2.000 ± 44
1 kHz	20	200 mV	2, 3	200.0 ± 1
2 MHz	20	200 mV	4, R122	200.0 ± 44
2 MHz	20	2 V	4	0.200 ± 8
100 kHz	20	2 V	4	0.200 ± 2
100 kHz	20	200 mV	4, R122	200.0 ± 6
50 Hz	20	200 mV	4	200.0 ± 6
50 Hz	20	2 V	4	0.200 ± 2
20 Hz	20	2 V	4	0.200 ± 44
20 Hz	20	200 mV	4	200.0 ± 8
1 kHz	40	20 mV	2, 3	20.00 ± 1
2 MHz	40	20 mV	4, R122	20.00 ± 49
2 MHz	40	200 mV	4	020.0 ± 8*
100 kHz	40	200 mV	4	020.0 ± 2
100 kHz	40	20 mV	4, R122	20.00 ± 7
50 Hz	40	20 mV	4	20.00 ± 7
50 Hz	40	200 mV	4	020.0 ± 2
20 Hz	40	200 mV	4	020.0 ± 8
20 Hz	40	20 mV	4	20.00 ± 49
1 kHz	60	2 mV	2, 3	2.000 ± 10
2 MHz	60	2 mV	4, R122	2.000 ± 94
2 MHz	60	20 mV	4	02.00 ± 13
100 kHz	60	20 mV	4	02.00 ± 3
100 kHz	60	2 mV	4, R122	2.000 ± 16
50 Hz	60	2 mV	4	2.000 ± 16
50 Hz	60	20 mV	4	02.00 ± 3
20 Hz	60	20 mV	4	02.00 ± 13
20 Hz	60	2 mV	4	2.000 ± 94
1 kHz	80	2 mV	2, 3	0.200 ± 10
2 MHz	80	2 mV	4	0.200 ± 58
100 kHz	80	2 mV	4	0.200 ± 12
50 Hz	80	2 mV	4	0.200 ± 12
20 Hz	80	2 mV	4	0.200 ± 58
1 kHz	0	2 V	2, 3	2.000 ± 1
2 MHz	0	20 V	4, C120	*
100 kHz	0	20 V	4	02.00 ± 2
50 Hz	0	20 V	4	02.00 ± 2
20 Hz	0	20 V	4	02.00 ± 8

* The second reading (at 2 MHz, 0 dB, and 20 V range) should be the same as the 2-MHz, 40-dB 200-mV range indication.

RESISTANCE

a. Connect the standard 1-k Ω resistor to the input terminals, set the measurement switch to k Ω , and adjust R156 for a readout of 1.000 k Ω .

b. Set the measurement switch to M Ω and adjust R158 for a readout of 1.000 k Ω .

c. Replace the 1-k Ω resistor with the precision 1-M Ω resistor; the readout should indicate 1.000 M Ω .

d. Using the Type 1433-H Decade Resistor, check several points on each range.

CURRENT

There are no separate adjustments for calibration of the μ A and nA ranges, which depend on the dc voltage calibrations (use paragraph 4.3.7 as a check).

4.6 TROUBLE ANALYSIS.

4.6.1 DC AMPLIFIER

AND PHOTOCOPPER CIRCUITS.

If improper functioning of the digital voltmeter has been isolated by substitution to the Type 1820-P2, or if the symptoms (see Table 5-3 in the Type 1820-A manual) exhibited point to plug-in troubles, proceed as follows (also see Figures 4-2 and 5-1):

a. Open the feedback loop by connecting AT212 in the plug-in to ground with a clip lead.

b. Apply a small dc voltage to the input terminals and look at the signal at AT108 of the plug-in with an oscilloscope. This signal should be a square wave with the corners rounded.

c. If the signal at AT203 does not resemble a square wave, look at the signal at AT223, which should be a square wave with about one seventh the amplitude of that at AT203. If this signal is present, remove and test Q201, Q202, and Q203.

d. If the photocopper output at AT223 is not as it should be, assuming that the neon-bulb drivers are functioning properly (paragraph 5.7.1 in the Type 1820-A manual), take off the metal cover of the photocopper assembly and check to see that the neon bulbs are firmly against the lucite rods and the rods firmly against the photo resistors. Turn on the instrument and observe whether both neon bulbs are lighting. If the bulbs are lighting properly, turn off the power and replace the metal cover on the photocopper.

4.6.2 AC AMPLIFIER AND RECTIFIER CIRCUITS.

If the voltmeter makes dc measurements correctly, but fails in some way to make ac measurements, the difficulty is located on the plug-in ac circuit board (see Figures 4-2 and 5-3).

If the fuse F101 blows when signals greater than 2-V rms are applied and the RANGE switch is on AUTO, the relays K101 and K102 may be sticking or the BCD information from the main frame may be wrong. Similarly, if the voltmeter displays are off by factors of 10 on some ranges occasionally, one of the other relays may be sticking. In this case, apply a sequence of increasing voltages in successive ranges and watch the relays in the plug-in to see if they change in accordance with the gain table on the schematic diagram (Figure 5-2).

If the ac amplifier seems to have failed altogether, i.e., when an ac voltage is applied no signal appears at AT113, apply a 2-V, 1-kHz signal to the input and trace the signal through at the collectors of Q101, Q103, Q104, and Q106 to isolate a possible transistor failure. If the signal exists at Q106C, but no corresponding dc level occurs at AT113, remove and test CR107 and CR108.

If all ac measurements are inaccurate or unstable, suspect the power regulator Q901 and its reference CR105, or the voltage reference CR104.

Parts Lists and Diagrams—Section 5

PARTS LIST

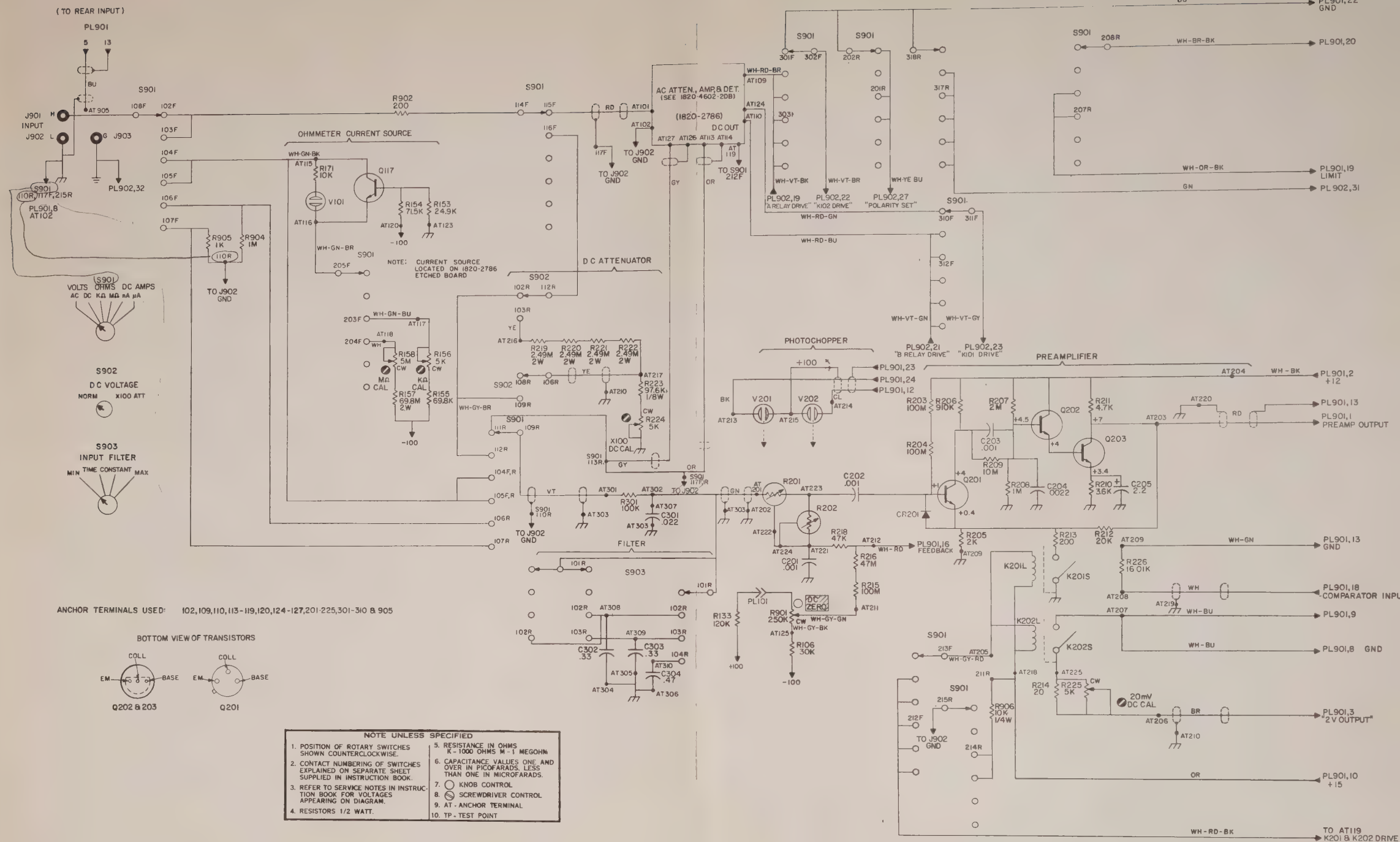
Ref. No.	Description	Part No.	Fed. Mfg. Code	Mfg. Part No.	Fed. Stock No.
CAPACITORS					
C101	Plastic, 0.47 μ F $\pm 10\%$ 200 V	4860-8247	84411	663UW, 0.47 μ F $\pm 10\%$	
C102	Ceramic, 8.2 pF $\pm 5\%$ 500 V	4400-0950	95121	GA, 8.2 pF $\pm 5\%$	
C103	Mica, 0.001 μ F $\pm 1\%$	4600-1100	14655	5A, 0.001 μ F $\pm 1\%$	
C104	Electrolytic, 0.47 μ F $\pm 20\%$ 75 V	4450-4310	56289	150D474X0075A2	
C105	Electrolytic, 3.3 μ F $\pm 20\%$ 15 V	4450-4600	56289	150D335X0015A2	5910-837-9325
C106	Mica, 820 pF $\pm 5\%$ 300 V	4680-3100	81349	CM20D821J	
C107	Electrolytic, 4.7 μ F $\pm 20\%$ 50 V	4450-4990	56289	150D475X0050B2	
C108	Ceramic, 0.01 μ F ± 80 -20% 500 V	4406-3109	72982	811, 0.01 μ F ± 80 -20%	5910-977-7579
C109	Electrolytic, 18 μ F $\pm 20\%$ 50 V	4450-5611	37942	TT, 18 μ F $\pm 20\%$	
C110	Electrolytic, 180 μ F $\pm 20\%$ 6 V	4450-5617	56289	150D187X0006R2	
C111	Electrolytic, 10 μ F ± 100 -10% 150 V	4450-3100	56289	D33610	5910-723-2517
C112	Electrolytic, 1 μ F $\pm 20\%$ 35 V	4450-4300	56289	150D105X0035A2	5910-726-5003
C113	Plastic, 0.0047 μ F $\pm 5\%$ 100 V	4860-7398	84411	663UW, 0.0047 μ F $\pm 5\%$	
C114	Electrolytic, 1 μ F $\pm 20\%$ 35 V	4450-4300	56289	150D105X0035A2	5910-726-5003
C115	Plastic, 10 μ F $\pm 20\%$ 50 V	4860-9855	84411	663F, 10 μ F $\pm 20\%$	
C116	Electrolytic, 22 μ F $\pm 20\%$ 15 V	4450-5300	56289	150D226X0015B2	5910-752-4270
C117	Electrolytic, 22 μ F $\pm 20\%$ 15 V	4450-5300	56289	150D226X0015B2	5910-752-4270
C118	Electrolytic, 200 μ F ± 100 -10% 6 V	4450-2610	37942	TT, 200 μ F ± 100 -10%	5910-945-1836
C119	Plastic, 2.2 μ F $\pm 10\%$ 50 V	4860-8300	84411	620S22591	
C120	Air, 1.2 to 3.5 pF $\pm 10\%$	4380-6003	74970	189-1-1, 1.2 to 3.5 pF $\pm 10\%$	
C121	Electrolytic, 1 μ F $\pm 20\%$ 35 V	4450-4300	56289	150D105X0035A2	5910-726-5003
C122	Ceramic, 0.01 μ F ± 80 -20% 500 V	4406-3109	72982	811, 0.01 μ F ± 80 -20%	5910-977-7579
C123	Electrolytic, 10 μ F ± 100 -10% 150 V	4450-3100	56289	D33610	5910-799-9286
C124	Electrolytic, 4.7 μ F $\pm 20\%$ 50 V	4450-4990	56289	150D475X0050B2	
C125	Electrolytic, 3.3 μ F $\pm 20\%$ 75 V	4450-4980	56289	150D335X0075B2	
C126	Electrolytic, 15 μ F ± 100 -10% 100 V	4450-5597	37942	20, 15 μ F ± 100 -10%	
C127	Electrolytic, 0.47 μ F $\pm 20\%$ 75 V	4450-4310	56289	150D474X0075A2	
C128	Electrolytic, 15 μ F ± 100 -10% 100 V	4450-5597	37942	20, 15 μ F ± 100 -10%	
C129	Ceramic, 0.1 μ F ± 80 -20% 50 V	4403-4100	80131	CC63, 0.1 μ F ± 80 -20%	5910-811-4788
C130	Ceramic, 10 pF $\pm 5\%$ 500 V	4400-1000	78488	GA, 10 pF $\pm 5\%$	
C131	Ceramic, 22 pF $\pm 5\%$ 500 V	4417-0225	80131	CC60, 22 pF $\pm 5\%$	
C132	Electrolytic, 0.68 μ F $\pm 10\%$ 50 V	4450-4315	56289	150D684X0050A2	
C201	Plastic, 0.001 μ F $\pm 10\%$ 400 V	4863-2109	56289	194P10394	
C202	Plastic, 0.001 μ F $\pm 10\%$ 400 V	4863-2109	56289	194P10394	
C203	Ceramic, 0.001 μ F ± 80 -20% 500 V	4404-2109	72982	831, 0.001 μ F ± 80 -20%	5910-983-9994
C204	Ceramic, 0.0022 μ F ± 80 -20% 500 V	4404-2229	72982	831, 0.0022 μ F ± 80 -20%	
C205	Electrolytic, 2.2 μ F $\pm 20\%$ 20 V	4450-4500	56289	150D225X0020A2	5910-976-4604
C301	Plastic, 0.022 μ F $\pm 10\%$ 400 V	4863-3229	56289	194P22394	
C302	Plastic, 0.33 μ F $\pm 10\%$ 400 V	4860-9700	84411	663F, 0.22 μ F $\pm 10\%$	
C303	Plastic, 0.33 μ F $\pm 10\%$ 400 V	4860-9700	84411	663F, 0.33 μ F $\pm 10\%$	
C304	Plastic, 0.47 μ F $\pm 10\%$ 400 V	4860-9725	84411	663F, 0.47 μ F $\pm 10\%$	
RESISTORS					
R101	Film, 1 M Ω $\pm 1\%$ 1/2 W	6450-4100	75042	CEC, 1 M Ω $\pm 1\%$	5905-539-4565
R102	Film, 10.1 k Ω $\pm 1\%$ 1/4 W	6350-2101	75042	CEB, 10.1 k Ω $\pm 1\%$	
R103	Potentiometer, 500 Ω $\pm 5\%$	6058-1505	75042	CT-100, 500 Ω $\pm 5\%$	
R104	Composition, 56 k Ω $\pm 5\%$ 1/4 W	6099-3565	75042	BTS, 56 k Ω $\pm 5\%$	5905-800-0179
R105	Composition, 51 k Ω $\pm 5\%$ 1/4 W	6099-3515	75042	BTS, 51 k Ω $\pm 5\%$	5905-200-6731
R106	Composition, 51 k Ω $\pm 5\%$ 1/4 W	6099-3515	75042	BTS, 51 k Ω $\pm 5\%$	5905-200-6731
R107	Composition, 1 M Ω $\pm 5\%$ 1/4 W	6099-5105	75042	BTS, 1 M Ω $\pm 5\%$	
R108	Composition, 1 M Ω $\pm 5\%$ 1/4 W	6099-5105	75042	BTS, 1 M Ω $\pm 5\%$	
R109	Film, 75 k Ω $\pm 1\%$ 1/8 W	6250-2750	75042	BTS, 75 k Ω $\pm 1\%$	
R110	Composition, 56 Ω $\pm 5\%$ 1/4 W	6099-0565	75042	BTS, 56 Ω $\pm 5\%$	
R111	Film, 13 k Ω $\pm 1\%$ 1/2 W	6450-2130	75042	BTS, 13 k Ω $\pm 1\%$	
R112	Film, 180 k Ω $\pm 1\%$ 1/8 W	6251-3180	75042	CEA-TO, 180 k Ω $\pm 1\%$	
R113	Film, 5.62 k Ω $\pm 1\%$ 1/2 W	6450-1562	75042	CEC, 5.62 k Ω $\pm 1\%$	
R114	Film, 137 Ω $\pm 1\%$ 1/8 W	6250-0137	75042	CEA, 137 Ω $\pm 1\%$	
R115	Potentiometer, 10 Ω $\pm 5\%$	6058-0105	75042	CT-100, 10 Ω $\pm 10\%$	
R116	Composition, 100 Ω $\pm 5\%$ 1/4 W	6099-1105	75042	BTS, 100 Ω $\pm 5\%$	
R117	Film, 1.5 k Ω $\pm 1\%$ 1/8 W	6250-1150	75042	CEA, 1.5 k Ω $\pm 1\%$	5905-581-6913
R118	Film, 13.3 k Ω $\pm 1\%$ 1/8 W	6250-2133	75042	CEA, 13.3 k Ω $\pm 1\%$	
R119	Composition, 5.1 M Ω $\pm 5\%$ 1/4 W	6099-5515	75042	BTS, 5.1 M Ω $\pm 5\%$	
R120	Film, 75 k Ω $\pm 1\%$ 1/4 W	6350-2750	75042	CEB, 75 k Ω $\pm 1\%$	
R121	Film, 33.2 k Ω $\pm 1\%$ 1/8 W	6250-2332	75042	CEA, 33.2 k Ω $\pm 1\%$	
R122	Potentiometer, 20 Ω $\pm 30\%$	6049-0101	98474	62PR20	
R123	Film, 5.11 k Ω $\pm 1\%$ 1/2 W	6450-1511	75042	CEC-TO, 5.11 k Ω $\pm 1\%$	
R124	Film, 5.62 k Ω $\pm 1\%$ 1/2 W	6450-1562	75042	CEC-TO, 5.62 k Ω $\pm 1\%$	
R125	Film, 5.62 k Ω $\pm 1\%$ 1/2 W	6450-1562	75042	CEC-TO, 5.62 k Ω $\pm 1\%$	
R126	Composition, 100 k Ω $\pm 5\%$ 1/4 W	6099-4105	75042	BTS, 100 k Ω $\pm 5\%$	5905-686-3129
R127	Film, 2.21 k Ω $\pm 1\%$ 1/8 W	6250-1221	75042	CEA, 2.21 k Ω $\pm 1\%$	
R128	Film, 2.21 k Ω $\pm 1\%$ 1/8 W	6250-1221	75042	CEA, 2.21 k Ω $\pm 1\%$	
R129	Film, 931 Ω $\pm 1\%$ 1/8 W	6250-0931	75042	CEA, 931 Ω $\pm 1\%$	
R130	Film, 95.3 Ω $\pm 1\%$ 1/8 W	6250-9953	75042	CEA, 95.3 Ω $\pm 1\%$	
R131	Composition, 100 k Ω $\pm 5\%$ 1/4 W	6099-4105	75042	BTS, 100 k Ω $\pm 5\%$	5905-686-3129
R132	Potentiometer, 10 Ω $\pm 10\%$ 1 W	6058-0105	75042	CT-100, 10 Ω $\pm 10\%$	
R134	Composition, 15 Ω $\pm 5\%$ 1/4 W	6099-0155	75042	BTS, 15 Ω $\pm 5\%$	
R136	Composition, 4.7 k Ω $\pm 5\%$ 1/4 W	6099-2475	75042	BTS, 4.7 k Ω $\pm 5\%$	5905-686-9998
R137	Potentiometer, 100 Ω $\pm 5\%$	6058-1105	75042	CT-100, 100 Ω $\pm 5\%$	
R139	Composition, 43 k Ω $\pm 5\%$ 1/4 W	6099-3435	75042	BTS, 43 k Ω $\pm 5\%$	5905-549-9833

PARTS LIST (Cont.)

Ref. No.	Description	Part No.	Fed. Mfg. Code	Mfg. Part No.	Fed. Stock No.
R140	Composition, 43 kΩ ±5% 1/4 W	6099-3435	75042	BTS, 43 kΩ ±5%	5905-549-9833
R142	Composition, 100 kΩ ±5% 1/4 W	6099-4105	75042	BTS, 100 kΩ ±5%	5905-686-3129
R143	Composition, 43 kΩ ±5% 1/4 W	6099-3435	75042	BTS, 43 kΩ ±5%	5905-549-9833
R146	Composition, 10 kΩ ±5% 1/4 W	6099-3105	75042	BTS, 10 kΩ ±5%	5905-683-2238
R148	Composition, 22 kΩ ±5% 1/4 W	6099-3225	75042	BTS, 22 kΩ ±5%	5905-687-0002
R149	Composition, 100 kΩ ±5% 1/4 W	6099-4105	75042	BTS, 100 kΩ ±5%	5905-686-3129
R152	Composition, 20 kΩ ±5% 1/4 W	6099-3205	75042	BTS, 20 kΩ ±5%	5905-686-3368
R153	Film, 24.9 kΩ ±1% 1/4 W	6350-2249	75042	CEB, 24.9 kΩ ±1%	
R154	Film, 71.5 kΩ ±1% 1/4 W	6350-2715	75042	CEB, 71.5 kΩ ±1%	
R155	Film, 69.8 kΩ ±1% 1/4 W	6350-2698	75042	CEB, 69.8 kΩ ±1%	
R156	5 kΩ ±5%	6058-2505	75042	CT-100, 5 kΩ ±5%	
R157	Film, 69.8 MΩ ±1% 2 W	6590-5698	75042	MDH, 69.8 MΩ ±1%	
R158	Potentiometer, Wire Wound, 5 kΩ ±5%	6040-1650	01121	FWR, 5 MΩ ±20%	
R160	Film, 69.8 MΩ ±1% 2 W	6099-3435	75042	BTS, 43 kΩ ±5%	5905-549-9833
R161	Potentiometer, Composition, 5 MΩ ±20%	6099-4105	75042	BTS, 100 kΩ ±5%	
R162	Composition, 43 kΩ ±5% 1/4 W	6099-3435	75042	BTS, 43 kΩ ±5%	5905-549-9833
R164	Composition, 100 kΩ ±5% 1/4 W	6099-4105	75042	BTS, 100 kΩ ±5%	
R167	Composition, 100 kΩ ±5% 1/4 W	6099-4105	75042	BTS, 100 kΩ ±5%	
R168	Composition, 43 kΩ ±5% 1/4 W	6099-3435	75042	BTS, 43 kΩ ±5%	
R169	Composition, 100 kΩ ±5% 1/4 W	6099-4105	75042	BTS, 100 kΩ ±5%	5905-686-3129
R170	Composition, 13 kΩ ±5% 1/2 W	6100-3135	01121	RC20GF133J	5905-279-2669
R171	Composition, 10 kΩ ±5% 1/2 W	6100-3105	01121	RC20GF103J	5905-185-8510
R172	Composition, 100 kΩ ±5% 1/4 W	6099-4105	75042	BTS, 100 kΩ ±5%	5905-686-3129
R173	Composition, 100 kΩ ±5% 1/4 W	6099-4105	75042	BTS, 100 kΩ ±5%	5905-686-3129
R174	Composition, 4.7 Ω ±5% 1/4 W	6099-9475	75042	BTS, 4.7 Ω ±5%	
R175	Composition, 56 kΩ ±5% 1/4 W	6099-3565	75042	BTS, 56 kΩ ±5%	5905-800-0179
R176	Composition, 56 kΩ ±5% 1/4 W	6099-3565	75042	NSL-384CS	5905-800-0179
R201	Photo Conductor	6740-2033	12040	NSL-384CS	
R202	Photo Conductor	6740-2033	12040	NSL-384CS	
R203	Composition, 100 MΩ ±5% 1/2 W	6100-7105	01121	EB, 100 MΩ ±5%	
R204	Composition, 100 MΩ ±5% 1/2 W	6100-7105	01121	EB, 100 MΩ ±5%	
R205	Composition, 2 kΩ ±5% 1/2 W	6100-2205	01121	RC20GF202J	5905-190-8887
R206	Composition, 910 kΩ ±5% 1/2 W	6100-4915	01121	RC20GF914J	5905-221-5853
R207	Composition, 2 MΩ ±5% 1/2 W	6100-5205	01121	RC20GF205J	5905-279-1875
R208	Composition, 1 MΩ ±5% 1/2 W	6100-5105	01121	RC20GF105J	5905-192-0390
R209	Composition, 10 MΩ ±5% 1/2 W	6100-6105	01121	RC20GF106J	5905-279-1865
R210	Composition, 3.6 kΩ ±5% 1/2 W	6100-2365	01121	RC20GF362J	5905-171-2001
R211	Composition, 4.7 kΩ ±5% 1/2 W	6100-2475	01121	RC20GF472J	5905-279-3504
R212	Composition, 20 kΩ ±5% 1/2 W	6100-3205	01121	RC20GF203J	5905-192-0649
R213	Composition, 200 Ω ±5% 1/2 W	6100-1205	01121	RC20GF201J	5905-279-2674
R214	Wire Wound, 20 Ω ±0.15%	6983-2000	24655	6983-2000	
R215	Composition, 100 MΩ ±5% 1/2 W	6100-7105	01121	EB, 100 MΩ ±5%	
R216	Composition, 47 MΩ ±5% 1/2 W	6100-6475	01121	RC20GF476J	5905-794-3893
R218	Composition, 47 kΩ ±5% 1/2 W	6100-3475	01121	RC20GF473J	5905-254-9201
R219	Film, 2.49 MΩ ±1% 1 W	6550-4249	75042	MEF, 2.49 MΩ ±1%	5905-646-5940
R220	Film, 2.49 MΩ ±1% 1 W	6550-4249	75042	MEF, 2.49 MΩ ±1%	5905-646-5940
R221	Film, 2.49 MΩ ±1% 1 W	6550-4249	75042	MEF, 2.49 MΩ ±1%	5905-646-5940
R222	Film, 2.49 MΩ ±1% 1 W	6550-4249	75042	MEF, 2.49 MΩ ±1%	5905-646-5940
R223	Film, 97.6 kΩ ±1% 1/8 W	6250-2976	75042	CEA, 97.6 kΩ ±1%	5905-799-7487
R224	Potentiometer, 5 kΩ ±10%	6051-2509	80294	3007P-1-502	
R225	Potentiometer, 5 kΩ ±10%	6051-2509	80294	3007P-1-502	
R226	Wire Wound, 16.01 kΩ ±0.01%	6983-5010	24655	6983-5010	
R301	Composition, 100 kΩ ±1% 1/2 W	6100-4105	01121	RC20GF104J	5905-195-6761
R901	Potentiometer, 250 kΩ ±10%	6010-2000	01121	JU, 250 kΩ ±10%	5905-911-4406
R902	Composition, 200 Ω ±5% 1/2 W	6100-1205	01121	RC20GF201J	5905-279-2674
R903	Composition, 100 kΩ ±5% 1/4 W	6099-4105	75042	BTS, 100 kΩ ±5%	5905-686-3129
R904	Film, 1 MΩ ±1% 1/4 W	6351-4100	75042	CEB-TO, 1 MΩ ±1%	
R905	Film, 1 kΩ ±1% 1/4 W	6350-1100	75042	CEB, 1 kΩ ±1%	5905-892-7018
R906	Composition, 10 kΩ ±5% 1/4 W	6099-3105	75042	BTS, 10 kΩ ±5%	5905-683-2238
R907	Composition, 1 kΩ ±5% 2 W	6120-2105	01121	RC42GF102J	5905-256-3361
MISCELLANEOUS					
L101	CHOKE, Molded, 15 μH ±20%	4300-0100	99800	1837-00, 15 μH ±20%	
L102	CHOKE, Molded, 15 μH ±20%	4300-0100	99800	1537-00, 15 μH ±20%	
L103	CHOKE, Molded, 15 μH ±20%	4300-0100	99800	1537-00, 15 μH ±20%	
L104	CHOKE, Molded, 15 μH ±20%	4300-0100	99800	1537-00, 15 μH ±20%	
CR101	DIODE, Type 1N3604	6082-1001	24446	1N3604	5960-995-2199
CR102	DIODE, Type 1N3604	6082-1001	24446	1N3604	5960-995-2199
CR103	DIODE, Type 1N3604	6082-1001	24446	1N3604	5960-995-2199
CR104	DIODE, Type 1N969B	6083-1058	04713	1N969B	
CR105	DIODE, Type 1N978B	6083-1052	80131	1N978B	5960-858-4212
CR106	DIODE, Type 1N3604	6082-1001	24446	1N3604	5960-995-2199
CR107	DIODE, Type 1N3604	6082-1001	24446	1N3604	
CR108	DIODE, Type 1N3604	6082-1001	24446	1N3604	
CR109	DIODE, Type 1N645	6082-1016	24446	1N645	5961-944-8222
CR110	DIODE, Type 1N645	6082-1016	24446	1N645	5961-944-8222
CR111	DIODE, Type 1N3604	6082-1001	24446	1N3604	5960-995-2199
CR112	DIODE, Type 1N750	6083-1003	07910	1N750	
CR201	DIODE, Type 1N3604	6082-1001	24446	1N3604	5960-995-2199
CR901	DIODE, Type LMZ-27.0A	6083-1032	79089	LMZ-27.0A	
CR902	DIODE, Type 1N645	6082-1016	24446	1N645	5961-944-8222
F101	FUSE, 1/10 A	5330-3100	71400	AGC, 0.1 Amp.	
J901	JACK	4060-0408	24655	4060-0408	
J902	JACK	4060-0418	24655	4060-0418	
J903	JACK	0938-3016	24655	0938-3016	
PL901	PLUG, Multiple Plug Connector	4220-5295	02660	26-4100-24P	
PL902	PLUG, Multiple Plug Connector	4220-5298	71785	26-4100-32P	
K202	RELAY ASM	1820-2110	24655	1820-2110	

PARTS LIST (Cont.)

Ref. No.	Description	Part No.	Fed. Mfg. Code	Mfg. Part No.	Fed. Stock No.
K101L	RELAY COIL	6090-1131	71707	XU-8242-P	
K102L	RELAY COIL	6090-1131	71707	XU-8242-P	
K103L	RELAY COIL	6090-1130	71707	XU-8242-P	
K104L	RELAY COIL	6090-1131	71707	XU-8242-P	
K105L	RELAY COIL	6090-1131	71707	XU-8242-P	
K106L	RELAY COIL	6090-1131	71707	XU-8242-P	
K107L	RELAY COIL	6090-1131	71707	XU-8242-P	
K108L	RELAY COIL	6090-1130	71707	XU-8242-P	
K109L	RELAY COIL	6090-1131	71707	XU-8242-P	
K110L	RELAY COIL	6090-1131	71707	XU-8242-P	
K201L	RELAY COIL	6090-1130	71707	XU-8242-P	
K101S	RELAY SWITCH	6090-1131	71707	XU-8242-P	
K102S	RELAY SWITCH	6090-0800	30874	76597S	
K103S	RELAY SWITCH	6090-0800	30874	76597S	
K104S	RELAY SWITCH	6090-0800	30874	76597S	
K105S	RELAY SWITCH	6090-0800	30874	76597S	
K106S	RELAY SWITCH	6090-0800	30874	76597S	
K107S	RELAY SWITCH	6090-0800	30874	76597S	
K108S	RELAY SWITCH	6090-0800	30874	76597S	
K109S	RELAY SWITCH	6090-0800	30874	76597S	
K110S	RELAY SWITCH	6090-0800	30874	76597S	
K201S	RELAY SWITCH	6090-1150	30874	765830	
S0901	SOCKET, Multiple Socket Connector	4230-3301	24655	4230-3301	
S901	SWITCH, Rotary Wafer Switch	7890-5190	24655	7890-5190	
S902	SWITCH, Rotary Wafer Switch	7890-5170	24655	7890-5170	
S903	SWITCH, Rotary Wafer Switch	7890-5180	24655	7890-5180	
Q101	TRANSISTOR, Type 2N4250	8210-1135	93916	2N4250	
Q102	TRANSISTOR, Type 2N3415	8210-1103	24454	2N3415	
Q103	TRANSISTOR, Type 2N3855A	8210-1100	24454	16L64	
Q104	TRANSISTOR, Type 2N3250	8210-1089	80211	2N3250	
Q105	TRANSISTOR, Type 2N3391A	8210-1092	24454	2N3391A	5961-945-4108
Q106	TRANSISTOR, Type 2N3855A	8210-1100	24454	16L-64	
Q107	TRANSISTOR, Type 2N3905	8210-1114	04713	2N3905	
Q108	TRANSISTOR, Type 2N3414	8210-1047	24446	2N3414	5961-989-2749
Q109	TRANSISTOR, Type 2N3414	8210-1047	24446	2N3414	5961-989-2749
Q110	TRANSISTOR, Type 2N3414	8210-1047	24446	2N3414	5961-989-2749
Q111	TRANSISTOR, Type 2N4384	8210-1131	93916	2N4384	
Q112	TRANSISTOR, Type 2N3414	8210-1047	24446	2N3414	5961-989-2749
Q113	TRANSISTOR, Type 2N3905	8210-1114	04713	2N3905	
Q114	TRANSISTOR, Type 2N3390	8210-1077	24454	2N3390	
Q116	TRANSISTOR, Type 2N3414	8210-1047	24446	2N3414	5961-989-2749
Q117	TRANSISTOR, Type 2N3414	8210-1047	24446	2N3414	5961-989-2749
Q201	TRANSISTOR, Type 2N930	8210-1042	01295	2N930	5960-083-1124
Q202	TRANSISTOR, Type 2N3390	8210-1077	24454	2N3390	
Q203	TRANSISTOR, Type 2N3414	8210-1047	24446	2N3414	5961-989-2749
Q901	TRANSISTOR, Type 2N1540	8210-1540	80211	2N1540	
V101	TUBE	8390-0670	24455	NE76	
V201	TUBE, Type A1C	8390-0320	24455	A1C	
V202	TUBE, Type A1C	8390-0320	24455	A1C	



NOTE: The number appearing on the foil side is not the part number. The dot on the foil at the transistor socket indicates the collector lead.

Figure 5-3. The ac amplifier and precision rectifier.

From Federal Supply Code for Manufacturers Cataloging Handbooks H4-1 (Name to Code) and H4-2 (Code to Name) as supplemented through June, 1967

Rotary switch sections are shown as viewed from the panel end of the shaft. The first digit of the contact number refers to the section. The section nearest the panel is 1, the next section back is 2, etc. The next two digits refer to the contact. Contact 01 is the first position clockwise from a strut screw (usually the screw above the locating key), and the other contacts are numbered sequentially (02, 03, 04, etc.), proceeding clockwise around the section. A suffix F or R indicates that the contact is on the front or rear of the section, respectively.



Type 1820-P3 DIFFERENTIAL ADAPTOR

P/N 1820-9603

(Used only in the Type 1820 Digital Voltmeter)

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Specifications



Type 1820-P3 with Type 1820-A/1820-P2.

Input: Floating, symmetrical configuration.

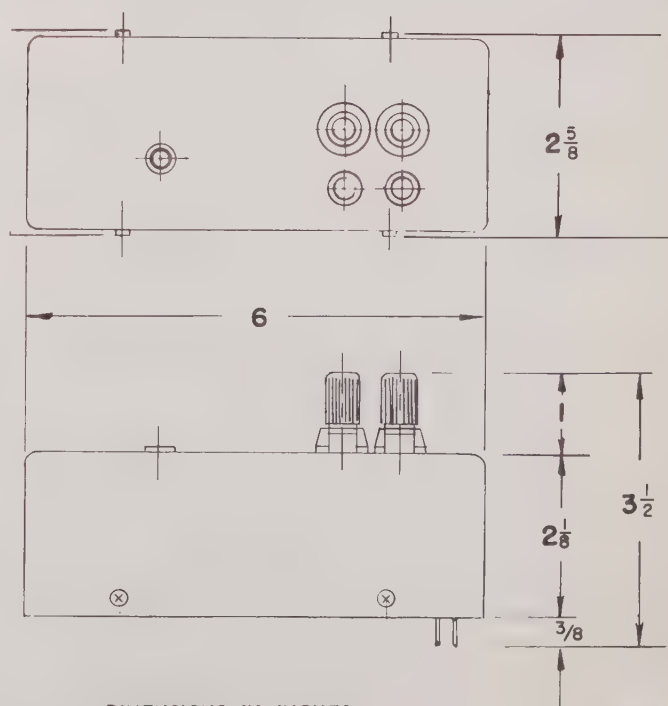
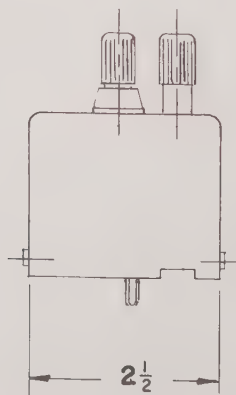
Common-Mode Rejection: >100 dB at dc and 60 Hz with 1-k Ω source impedance; 10 dB less with 100-k Ω source impedance.

Noise: 5 μ V at 3 Ω .

Drift: 0.1 μ V/ $^{\circ}$ C.

Mounting: Plugs into front-panel input terminals of either 1820-P1 or 1820-P2 plug-in.

Weight: Net, 11 oz (0.4 kg); shipping, 3 lb (1.4 kg).



DIMENSIONS IN INCHES

Introduction—Section 1

1.1 PURPOSE.

The Type 1820-P3 Differential Adaptor, an accessory for the Type 1820 Digital Voltmeter, improves the common-mode rejection and presents floating symmetrical input terminals to the voltmeter. It can be used with either the Type 1820-P1 Dc Multimeter/UHF Voltmeter or the Type 1820-P2 Ac/Dc Millivoltmeter. The common-mode rejection of the Type 1820-P3 is greater than 100 dB at dc and 60 Hz.

1.2 DESCRIPTION.

The Type 1820-P3 consists of a sampling capacitor, a set of relays, and a multivibrator. These components are mounted in a compact unit that plugs into the input terminals of the voltmeter plug-in preamplifier.

1.3 CONNECTORS.

The connectors of the Type 1820-P3 Differential Adaptor are listed in Table 1-1.

1.4 INSTALLATION.

To install the Type 1820-P3, hold it so that the A and B input jacks are to the right, and insert the three banana plugs on the underside of the unit into the input terminals of the Type 1820 plug-in preamplifier. Slide the banana plugs part way into their jacks, and line up the 2-connector Jones plug on the right side of the differential adaptor with the socket on the plug-in unit. Press the differential-adaptor plugs firmly into their sockets on the plug-in unit. Lock the differential adaptor in by turning the lock-plug screw clockwise.

TABLE 1-1
CONNECTORS

<i>Reference Designator</i>	<i>Name</i>	<i>Description</i>	<i>Function</i>
J101	A + jack	GR 274 insulated binding post	For connection of a positive dc input signal.
J102	B - jack	GR 274 insulated binding post	For connection of a negative dc input signal.
J103, J104		GR 274 uninsulated binding posts	Ground terminals.
PL102	LOCK plug	Locking banana plug	Locks into the chassis ground jack of the Type 1820 plug-in unit.
PL103, PL104		3/4-inch spaced banana plugs	For connection to input (high and low) terminals of the Type 1820 plug-in unit.
PL101		2-connector plug, Jones Part No. P-302-AB	For connection to +15-V supply in the Type 1820 plug-in unit.

Operating Procedure –Section 2

To measure a positive dc voltage with respect to ground, connect the signal to the A + terminal of the Type 1820-P3 and the circuit ground to either uninsulated binding post.

To measure the dc voltage between two points which are not at circuit ground, connect the higher

voltage to the A + terminal and the lower voltage to the B - terminal. Connect the circuit ground to one of the uninsulated binding posts.

See Section 2 of the Type 1820-A Manual for a list of the patch cords and adaptors available for mating with the Type 1820-P3.

Principles of Operation –Section 3

This unit is basically a sample-and-hold device with sampling time equal to holding time. The frequency of sampling is approximately 25 Hz.

During the sampling period, relays K101 and K102 are closed and relays K103 and K104 are open. Thus, the capacitor C101 charges to the potential of the input voltage. During the holding period, the relays K101 and K102 are open and K103 and K104 are closed. Thus the capacitor C101, which was charged to the input potential, is now connected to the input terminals of the DVM through an RC filter, R108 and C102.

The operation of the relays is such that one pair of relays always opens before the other pair closes. This is to avoid momentary direct connection of the input voltage to the input terminals of the DVM.

The dc common-mode-voltage rejection is limited by the capacitance from the junction of relays 1 and 3 to case ground, because this capacitance and C1 make a capacitive voltage divider. Practically, it is possible to hold this stray capacitance to less than 1 pF. Since this capacitance is the limiting factor for dc common-mode rejection, the instrument is ideally suited for applications requiring high impedances between the two input terminals.

The common-mode rejection at 60 or 120 Hz will be better than at dc, because any ac common-mode voltages on C1 will be averaged to zero by the filter following it.

Service and Maintenance—Section 4

4.1 WARRANTY.

We warrant that each new instrument manufactured and sold by us is free from defects in material and workmanship and that, properly used, it will perform in full accordance with applicable specifications for a period of two years after original shipment. Any instrument or component that is found within the two-year period not to meet these standards after examination by our factory, District Office, or authorized repair agency personnel will be repaired or, at our option, replaced without charge, except for tubes or batteries that have given normal service.

4.2 SERVICE.

The two-year warranty stated above attests the quality of materials and workmanship in our products. When difficulties do occur, our service engineers will assist in any way possible. If the difficulty cannot be eliminated by use of the following service instructions, please write or phone our Service Department (see Condensed Operating Instructions), giving full information of the trouble and of steps taken to remedy it. Be sure to mention the tube and serial numbers of the instrument.

Before returning an instrument to General Radio for service, please write to our Service Department or nearest District Office, requesting a Returned Material Tag. Use of this tag will ensure proper handling and identification. For instruments not covered by the warranty, a purchase order should be forwarded to avoid unnecessary delay.

4.3 MINIMUM PERFORMANCE STANDARDS.

4.3.1 EQUIPMENT REQUIRED.

The equipment required to test the performance of the Type 1820-P3 is listed in Table 4-1.

4.3.2 COMMON MODE REJECTION TEST.

Test Conditions

- a. Connect the Type 1820-P3 to a Type 1820-P2/1820-A.
- b. Set the Type 1820-P2 to DC and the Type 1820-A to LINEAR FUNCTION, AUTO RANGING.
- c. Short the Type 1820-P3 A and B input terminals and adjust the DC ZERO for a zero readout on the Type 1820-A.
- d. Remove the short and connect a 1-k Ω resistor between the A and B terminals.

DC Common-Mode Rejection

- a. Apply 200 V dc between the A input and chassis ground of the Type 1820-P3. The Type 1820-A should indicate less than 2 mV (greater than 100 dB down).
- b. Replace the 1-k Ω resistor with 100 k Ω . The Type 1820-A indication should be less than 6.32 mV (greater than 90 dB down).

AC Common-Mode Rejection

- a. With 1 k Ω between the A and B input terminals, apply 100 V rms at 60 Hz between the A input and chassis ground. The Type 1820-A should indicate less than 1.4 mV (greater than 100 dB down for the peak value).
- b. Repeat the test with the ac signal applied to the B input.

TABLE 4-1
TEST EQUIPMENT

<i>Device</i>	<i>Necessary Specifications</i>	<i>Recommended Type</i>
Digital voltmeter	No substitution	GR 1820 Digital Voltmeter, preferably with a Type 1820-P2 Ac/Dc Millivoltmeter, although any plug-in preamplifier can be used.
Standard resistor	$\pm 1\%$ accuracy. Values: 1 k Ω 10 k Ω 100 k Ω	GR 500-M Resistor GR 500-J Resistor GR 500-U Resistor
Dc reference voltage source	± 200 V, $\pm 0.5\%$ accuracy.	Fluke Precision Voltage Calibrator Model 337 A

4.4 ACCESS TO COMPONENTS.

To obtain access to the components of the differential adaptor, remove the four small Phillips-head screws on the sides of the case. This will allow the case to be pulled up from the circuit board so that the wires from this board to the input terminals can be reached. Unsolder these wires and take the case completely off.

4.5 TROUBLE ANALYSIS.

Any difficulty with the differential adaptor will probably be due to sticking relays or failure of a transistor, either Q101 or Q102, in the multivibrator.

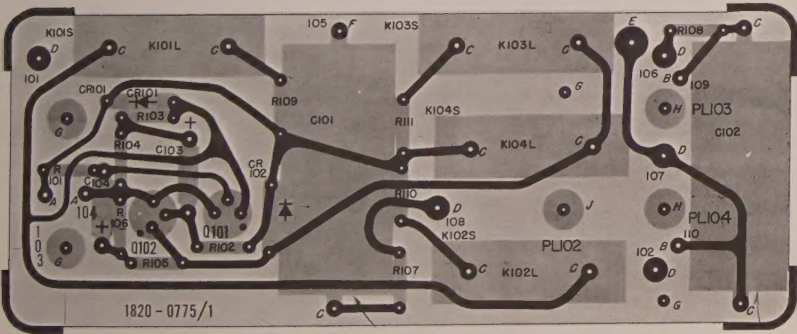
CAUTION

Application of a voltage greater than 200 V may damage C101.

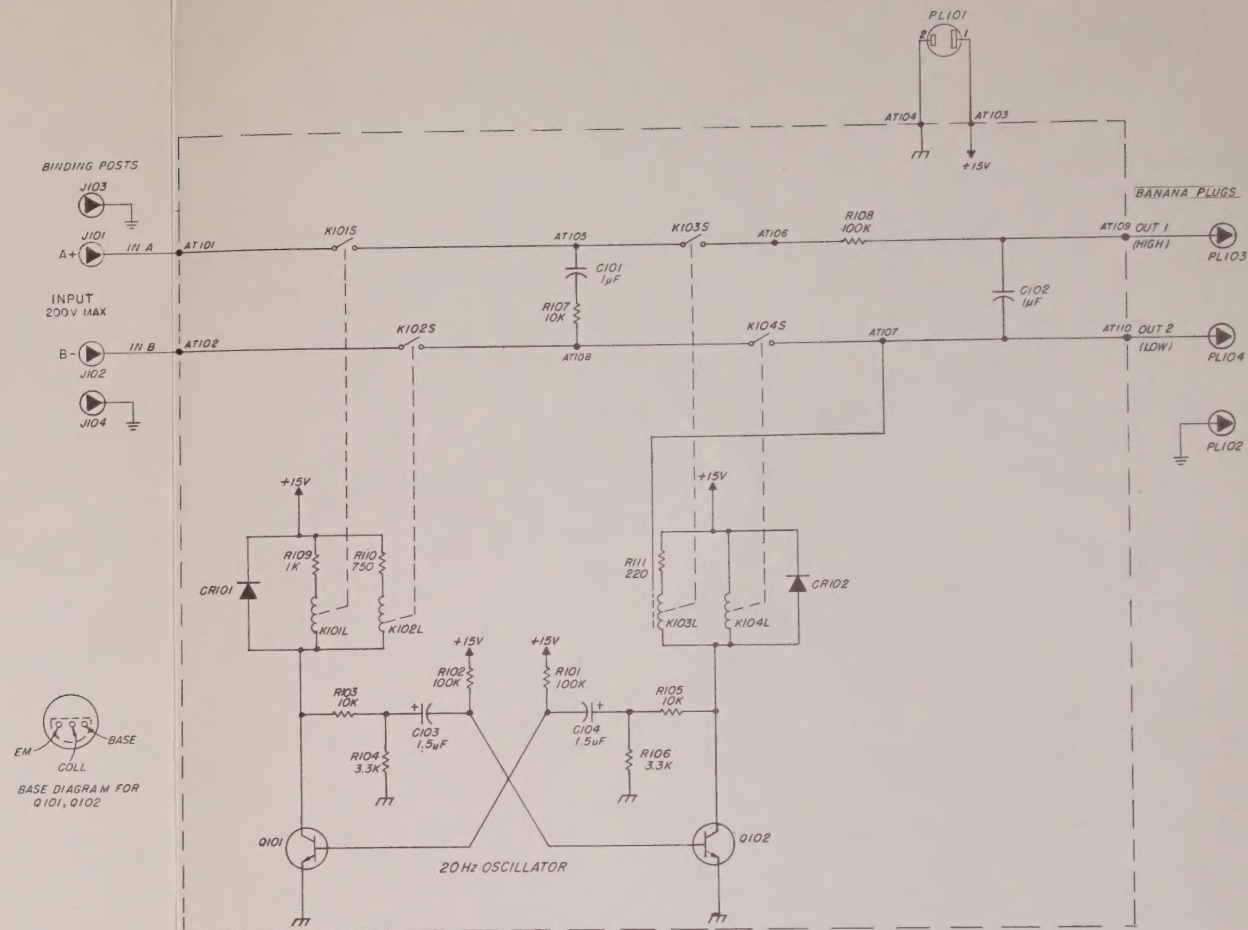
Parts Lists and Diagrams—Section 5

Ref No.	Description	Part No.	Fed. Mfg. Code	Mfg. Part No.	Fed. Stock No.
RESISTORS					
R101	Composition, 100 kΩ ±5% 1/4 W	6099-4105	75042	BTS, 100 kΩ ±5%	
R102	Composition, 100 kΩ ±5% 1/4 W	6099-4105	75042	BTS, 100 kΩ ±5%	
R103	Composition, 10 kΩ ±5% 1/4 W	6099-3105	75042	BTS, 10 kΩ ±5%	
R104	Composition, 3.3 kΩ ±5% 1/4 W	6099-2335	75042	BTS, 3.3 kΩ ±5%	
R105	Composition, 10 kΩ ±5% 1/4 W	6099-3105	75042	BTS, 10 kΩ ±5%	
R106	Composition, 3.3 kΩ ±5% 1/4 W	6099-2335	75042	BTS, 3.3 kΩ ±5%	
R107	Composition, 10 kΩ ±5% 1/4 W	6099-3105	75042	BTS, 10 kΩ ±5%	
R108	Composition, 100 kΩ ±5% 1/4 W	6099-4105	75042	BTS, 100 kΩ ±5%	
R109	Composition, 220 Ω ±5% 1/4 W	6099-2105	75042	BTS, 1 kΩ ±5%	
R110	Composition, 100 Ω ±5% 1/4 W	6099-1755	75042	BTS, 750 Ω ±5%	
R111	Composition, 220 Ω ±5% 1/4 W	6099-1225	75042	BTS, 220 Ω ±5%	
MISCELLANEOUS					
C101	CAPACITOR, Plastic, 1.0 μF ±10% 200 V 4860-8275	84411	663UW, 1.0 μF ±10%		
C102	CAPACITOR, Plastic, 1.0 μF ±10% 200 V 4860-8275	84411	663UW, 1.0 μF ±10%		
C103	CAPACITOR, Electrolytic, 1.5 μF ±20% 20 V	4450-4400	56289	150D155X0020A2	5910-670-7525
C104	CAPACITOR, Electrolytic, 1.5 μF ±20% 20 V	4450-4400	56289	150D155X0020A2	5910-670-7525
CR101	DIODE, Type 1N4442	6082-1009	24446	1N4442	5961-929-9967
CR102	DIODE, Type 1N4442	6082-1009	24446	1N4442	5961-929-9967
J101	JACK, Binding Post	0938-2032	24655	0938-2032	
J102	JACK, Binding Post	0938-2032	24655	0938-2032	
J103	JACK, Binding Post	0938-2013	24655	0938-2013	
J104	JACK, Binding Post	0938-2013	24655	0938-2013	
PL101	PLUG, Round	4220-4300	71785	P-302-AB	
PL102	PLUG	0274-3650	24655	0274-3650	
PL103	PLUG	0274-3650	24655	0274-3650	
PL104	PLUG, Locking	0274-1380	24655	0274-1380	
K101L thru K104L	RELAY COIL	6090-1170*	24655	6090-1170	
K101S thru K104S	RELAY SWITCH ASSEMBLY	1820-1060*	24655	1820-1060	
Q101	TRANSISTOR, Type 2N3390	8210-1077	24454	2N3390	
Q102	TRANSISTOR, Type 2N3390	8210-1077	24454	2N3390	
	Plug Assembly	0274-3650	24655	0274-3650	

NOTE: The number appearing on the foil side is not the part number. The dot on the foil at the transistor socket indicates the collector lead.



Type 1820-P3 Etched Board, P/N 1820-2776.



- NOTE: UNLESS SPECIFIED
1. POSITION OF ROTARY SWITCHES SHOWN COUNTERCLOCKWISE.
 2. CONTACT NUMBERING OF SWITCHES EXPLAINED ON SEPARATE SHEET SUPPLIED IN INSTRUCTION BOOK.
 3. REFER TO SERVICE NOTES IN INSTRUCTION BOOK FOR VOLTAGES APPEARING ON DIAGRAM.
 4. RESISTORS 1/4 WATT.
 5. RESISTANCE IN OHMS
K 1000 OHMS M 1 MEGOHM
 6. CAPACITANCE VALUES ONE AND OVER IN PICOFARADS, LESS THAN ONE IN MICROFARADS.
 7. KNOB CONTROL
 8. SCREWDRIIVER CONTROL
 9. AT ANCHOR TERMINAL
 10. TP TEST POINT

Type 1820-P3 Schematic Diagram.

FEDERAL MANUFACTURERS CODE

From Federal Supply Code for Manufacturers Cataloging Handbooks H4-1
(Name to Code) and H4-2 (Code to Name) as supplemented through June, 1967.

Code	Manufacturers Name and Address	Code	Manufacturers Name and Address	Code	Manufacturers Name and Address
00192	Jones Mfg. Co., Chicago, Illinois	53021	Shangamo Electric Co., Springfield, Ill. 62705	80583	Hammarlund Co. Inc., New York, N. Y.
00194	Waisco Electronics Corp., Los Angeles, Calif.	54294	Shallcross Mfg. Co., Selma, N. C.	80740	Beckman Instruments, Inc., Fullerton, Calif.
00656	Aerovox Corp., New Bedford, Mass.	54715	Shure Brothers, Inc., Evanston, Ill.	81073	Grayhill Inc., LaGrange, Ill. 60525
01009	Alden Products Co., Brockton, Mass.	56289	Sprague Electric Co., N. Adams, Mass.	81143	Isolantite Mfg. Corp., Stirling, N. J. 07980
01121	Allen-Bradley, Co., Milwaukee, Wisc.	59730	Thomas and Betts Co., Elizabeth, N. J. 07207	81349	Military Specifications
01295	Texas Instruments, Inc., Dallas, Texas	59875	TRW Inc. (Accessories Div), Cleveland, Ohio	81350	Joint Army-Navy Specifications
02114	Ferroxcube Corp. of America, Saugerties, N. Y. 12477	60399	Torrington Mfg. Co., Torrington, Conn.	81751	Columbus Electronics Corp., Yonkers, N. Y.
02606	Fenwal Lab. Inc., Morton Grove, Ill.	61637	Union Carbide Corp., New York, N. Y. 10017	81831	Filton Co., Flushing, L. I., N. Y.
02660	Amphenol Electronics Corp., Broadview, Ill.	61864	United-Carr Fastener Corp., Boston, Mass.	81860	Barry Controls Div. of Barry Wright Corp., Watertown, Mass.
02768	Fastex Division of Ill. Tool Works, Des Plaines, Ill. 60016	63060	Victoreen Instrument Co., Inc., Cleveland, Ohio	82219	Sylvania Electric Products, Inc., (Electronic Tube Div.), Emporium, Penn.
03508	G. E. Semiconductor Products Dept., Syracuse, N. Y. 13201	63743	Ward Leonard Electric Co., Mt. Vernon, N. Y.	82273	Indiana Pattern and Model Works, LaPort, Ind.
03636	Grayburne, Yonkers, N. Y. 10701	65083	Westinghouse (Lamp Div), Bloomfield, N. J.	82389	Switchcraft Inc., Chicago, Ill. 60630
03888	Pyrofilm Resistor Co., Cedar Knolls, N. J.	65092	Weston Instruments, Weston-Newark, Newark, N. J.	82647	Metals and Controls Inc., Attleboro, Mass.
03911	Clairex Corp., New York, N. Y. 10001	70485	Atlantic-India Rubber Works, Inc., Chicago, Ill. 60607	82807	Milwaukee Resistor Co., Milwaukee, Wisc.
04009	Arrow, Hart and Hegeman Electric Co., Hartford, Conn. 06106	70563	Amperite Co., Union City, N. J. 07087	83058	Carr Fastener Co., Cambridge, Mass.
04713	Motorola Semi-Conduct Product, Phoenix, Ariz. 85008	70903	Belden Mfg. Co., Chicago, Ill. 60644	83186	Victory Engineering Corp (IVECO), Springfield, N. J. 07081
05170	Engineered Electronics Co., Inc., Santa Ana, Calif. 92702	71126	Bronson, Homer D., Co., Beacon Falls, Conn.	83361	Bearing Specialty Co., San Francisco, Calif.
05624	Barber-Colman Co., Rockford, Ill. 61101	71294	Canfield, H. O. Co., Clifton Forge, Va. 24422	83587	Solar Electric Corp., Warren, Penn.
05820	Wakefield Eng., Inc., Wakefield, Mass. 01880	71400	Bussman Mfg. Div. of McGraw Edison Co., St. Louis, Mo.	83740	Union Carbide Corp., New York, N. Y. 10017
07127	Eagle Signal Div. of E. W. Bliss Co., Baraboo, Wisc.	71590	Centralab, Inc., Milwaukee, Wisc. 53212	84411	TRW Capacitor Div., Ogallala, Nebr.
07261	Avnet Corp., Culver City, Calif. 90230	71666	Continental Carbon Co., Inc., New York, N. Y.	84835	Lehigh Metal Products Corp., Cambridge, Mass. 02140
07263	Fairchild Camera and Instrument Corp., Mountain View, Calif.	71707	Coto Coil Co. Inc., Providence, R. I.		
07387	Birtcher Corp., No. Los Angeles, Calif.	71744	Chicago Miniature Lamp Works, Chicago, Ill.	84971	TA Mfg. Corp., Los Angeles, Calif.
07595	American Semiconductor Corp., Arlington Heights, Ill. 60004	71785	Cinch Mfg. Co. and Howard B. Jones Div., Chicago, Ill. 60624	86577	Precision Metal Products of Malden Inc., Stoneham, Mass. 02180
07828	Bodine Corp., Bridgeport, Conn. 06605	71823	Darnell Corp., Ltd., Downey, Calif. 90241	86684	RCA (Electrical Component and Devices) Harrison, N. J.
07829	Bodine Electric Co., Chicago, Ill. 60618	72136	Electro Motive Mfg. Co., Wilmington, Conn.	88140	Cutler-Hammer Inc., Lincoln, Ill.
07910	Continental Device Corp., Hawthorne, Calif.	72259	Nytronics Inc., Berkeley Heights, N. J. 07922	88219	Gould Nat. Batteries Inc., Trenton, N. J.
07983	State Labs Inc., N. Y., N. Y. 10003	72619	Dialight Co., Brooklyn, N. Y. 11237	88419	Cornell Dubilier Electric Corp., Fuquay-Varina, N. C.
07999	Amphenol Corp., Borg Inst. Div., Delaware, Wisc. 53115	72699	General Instrument Corp., Capacitor Div., Newark, N. J. 07104	88627	K and G Mfg. Co., New York, N. Y.
08730	Vemaline Prod. Co., Franklin Lakes, N. J.	72765	Drake Mfg. Co., Chicago, Ill. 60656	89482	Holtzer Cabot Corp., Boston, Mass.
09213	General Electric Semiconductor, Buffalo, N. Y.	72825	Hugh H. Eby, Inc., Philadelphia, Penn. 19144	89665	United Transformer Co., Chicago, Ill.
09823	Burgess Battery Co., Freeport, Ill.	72962	Elastic Stop Nut Corp., Union, N. J. 07083	90201	Mallory Capacitor Co., Indianapolis, Ind.
09922	Burdick Corp., Norwalk, Conn. 06852	72982	Erie Technological Products Inc., Erie, Penn.	90750	Westinghouse Electric Corp., Boston, Mass.
11599	Chandler Evans Corp., W. Hartford, Conn.	73559	Amperex Electronics Co., Hicksville, N. Y.	90952	Hardware Products Co., Reading, Penn. 19602
12498	Teledyn Inc., Crystalonics Div., Cambridge, Mass. 02140	73690	Carling Electric Co., W. Hartford, Conn.	91032	Continental Wire Corp., York, Penn. 17405
12672	RCA Commercial Receiving Tube and Semi- conductor Div., Woodridge, N.J.	73899	Elco Resistor Co., New York, N. Y.	91146	ITT Cannon Electric Inc., Salem, Mass.
12697	Clarostat Mfg. Co. Inc., Dover, N. H. 03820	74193	J. F. D. Electronics Corp., Brooklyn, N. Y.	91293	Johanson Mfg. Co., Bonton, N. J. 07005
12954	Dickson Electronics Corp., Scottsdale, Ariz.	74861	Heinemann Electric Co., Trenton, N. J.	91598	Chandler Co., Wethersfield, Conn. 06109
13327	Solitrone Devices, Tappan, N. Y. 10983	74970	Industrial Condenser Corp., Chicago, Ill.	91637	Dale Electronics Inc., Columbus, Nebr.
14433	ITT Semiconductors, W. Palm Beach, Florida	75042	E. F. Johnson Co., Waseca, Minn. 56093	91662	Elco Corp., Willow Grove, Penn.
14655	Cornell Dubilier Electric Co., Newark N. J.	75382	IRC Inc., Philadelphia, Penn. 19108	91719	General Instruments, Inc., Dallas, Texas
14674	Corning Glass Works, Corning, N. Y.	75608	Kulka Electric Corp., Mt. Vernon, N. Y.	91929	Honeywell Inc., Freeport, Ill.
14936	General Instrument Corp., Hicksville, N. Y.	75915	Linden and Co., Providence, R. I.	92519	Electra Insulation Corp., Woodside, Long Island, N. Y.
15238	ITT, Semiconductor Div. of Int. T. and T., Lawrence, Mass.	76005	Littelfuse, Inc., Des Plaines, Ill. 60016	92678	Edgerton, Germeshausen and Grier, Boston, Mass.
15605	Cutler-Hammer Inc., Milwaukee, Wisc. 53233	76487	Lord Mfg. Co., Erie, Penn. 16512	93332	Sylvania Electric Products, Inc., Woburn, Mass.
16037	Spruce Pine Mica Co., Spruce Pine, N. C.	76545	James Millen Mfg. Co., Malden, Mass. 02148	93916	Cramer Products Co., New York, N. Y. 10013
19701	Electra Mfg. Co., Independence, Kansas 67301	76684	Mueller Electric Co., Cleveland, Ohio 44114	94144	Raytheon Co. Components Div., Quincy, Mass.
21335	Fairair Bearing Co., New Briton, Conn.	76854	National Tube Co., Pittsburg, Penn.	94154	Tung Sol Electric Inc., Newark, N. J.
24446	G. E. Schenectady, N. Y. 12305	77147	Oak Mfg. Co., Crystal Lake, Ill.	95076	Garde Mfg. Co., Cumberland, R. I.
24454	G. E., Electronic Comp., Syracuse, N. Y.	77166	Patton MacGuer Co., Providence, R. I.	95146	Alco Electronics Mfg. Co., Lawrence, Mass.
24455	G. E. (Lamp Div), Nela Park, Cleveland, Ohio	77263	Pass-Seymour, Syracuse, N. Y.	95238	Continental Connector Corp., Woodside, N. Y.
24655	General Radio Co., W. Concord, Mass 01781	77339	Pierce Roberts Rubber Co., Trenton, N. J.	95275	Vitramon, Inc., Bridgeport, Conn.
26806	American Zettler Inc., Costa Mesa, Calif.	77542	Positive Lockwasher Co., Newark, N. J.	95354	Methode Mfg. Co., Chicago, Ill.
28520	Hayman Mfg. Co., Kenilworth, N. J.	77638	Ray-O-Vac Co., Madison, Wisc.	95412	General Electric Co., Schenectady, N. Y.
28959	Hoffman Electronics Corp., El Monte, Calif.	78189	TRW, Electronic Component Div., Camden, N. J. 08103	95794	Ansonda American Brass Co., Torrington, Conn.
30874	International Business Machines, Armonk, N.Y.	78277	General Instruments Corp., Brooklyn, N. Y.	96095	Hi-Q Div. of Aerovox Corp., Orlean, N. Y.
32001	Jensen Mfg. Co., Chicago, Ill. 60638	78488	Shakeproof Div. of Ill. Tool Works, Elgin, Ill. 60120	96214	Texas Instruments Inc., Dallas, Texas 75209
35929	Constanta Co. of Canada Limited, Montreal 19, Quebec	78553	Sigma Instruments Inc., S. Braintree, Mass.	96256	Thordarson-Meissner Div. of McGuire, Mt. Carmel, Ill.
37942	P. R. Mallory and Co. Inc., Indianapolis, Ind.	79089	Stackpole Carbon Co., St. Marys, Penn.	96341	Microwave Associates Inc., Burlington, Mass.
38443	Marlin-Rockwell Corp., Jamestown, N. Y.	79725	Tinnerman Products, Inc., Cleveland, Ohio	96906	Military Standards
40931	Honeywell Inc., Minneapolis, Minn. 55408	79963	RCA, Commercial Receiving Tube and Semi- conductor Div., Harrison, N. J.	97966	CBS Electronics Div. of Columbia Broadcast- ing Systems, Danvers, Mass.
42190	Muter Co., Chicago, Ill. 60638	80030	Prestole Fastener Div. Bishop and Babcock Corp., Toledo, Ohio	98291	Sealectro Corp., Mamaroneck, N. Y. 10544
42498	National Co. Inc., Melrose, Mass. 02176	80048	Vickers Inc. Electric Prod. Div., St. Louis, Mo.	98821	North Hills Electronics Inc., Glen Cove, N. Y.
43991	Norma-Hoffman Bearings Corp., Stanford, Conn. 06904	80131	Electronic Industries Assoc., Washington, D.C.	99180	Transitron Electronics Corp., Melrose, Mass.
49671	RCA, New York, N. Y.	80211	Motorola Inc., Franklin Park, Ill. 60131	99378	Atlee Corp., Winchester, Mass. 01890
49956	Raytheon Mfg. Co., Waltham, Mass. 02154	80258	Standard Oil Co., Lafayette, Ind.	99800	Delevan Electronics Corp., E. Aurora, N. Y.
		80294	Bourns Inc., Riverside, Calif. 92506	83033	Meissner Mfg., Div. of Maguire Industries, Inc., Mount Carmel, Illinois
		80431	Air Filter Corp., Milwaukee, Wisc. 53218		LRC Electronics, Horsesheds, New York
				80183	Sprague Products Co., N. Adams, Mass.

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